lake winnipeg, churchill & nelson rivers study board CANADA MANITOBA 1971-'75

existing works and services

technical
report
appendix
4

LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

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LAKE WINNIPEG
TEMPORARY DYKES INVESTIGATION

by

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June, 1974

for

THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SPECIAL NOTE

THE CONCLUSIONS AND RECOMMENDATIONS CONTAINED IN THIS APPENDIX ARE THOSE OF THE AUTHOR(S) AND ARE NOT NECESSARILY THE SAME AS THE CONCLUSIONS AND RECOMMENDATIONS OF THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD AS EXPRESSED IN THE SUMMARY REPORT AND THE TECHNICAL REPORT.

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RECOMMENDATIONS

It is recommended that an embankment material sampling program be initiated to provide further information as to the condition of the temporary dyking system. This information is necessary to accurately determine the amount of work required to upgrade the existing temporary dyking system to minimize the increased maintenance costs which it is anticipated will result from the proposed pattern of regulation.

Further measures such as rip-rap protection, grassed and trimmed slopes or willow planting should be considered for sections of the dyking system which are immediately adjacent to the Lake and are continually subject to erosion by wave action.

It would be desirable to continue the current program of dyke inspection and maintenance and it is recommended that interior drainage facilities and procedures be studied with the view of reducing the amount of annual charges for this type of maintenance.

INTRODUCTION

This report contains the results of investigations in the Lake Winnipeg Study Area concerning the existing temporary dyking system as outlined in Schedule 'A' of "Flood Damages Study Proposals", entitled "Hydrologic, Hydraulic and Geomorphic Proposals", of a Memorandum of Understanding between the Lake Winnipeg, Churchill and Nelson Rivers Study Board and the Water Resources Branch signed June 14, 1972.

A supplementary interim license issued to Manitoba Hydro by the Province of Manitoba, in August, 1972, and in accordance with the Water Power Act, gives Manitoba Hydro authority to regulate Lake Winnipeg between elevations 711 and 715, Geodetic Survey of Canada Datum , for water power development purposes. This utilization of the storage capacity of Lake Winnipeg will raise the mean and minimum lake levels above natural conditions and this increase in mean water levels may increase damage to the temporary dyking system around the southern portion of the Lake.

OBJECTIVES

The purpose of this study is to evaluate the effects of Lake Winnipeg Regulation on the existing temporary dyking system and to recommend measures which should be undertaken to ensure performance of these dykes. This entailed an investigation of the condition of the present temporary dyking system, a determination of the probability of failure of the dykes for anticipated regulated conditions on the Lake, and an estimate of potential damages in the event of failure of the dykes.

TERMS OF REFERENCE

The major portion of the area protected by the temporary dykes consists of agricultural crop land and pasture. Some urban properties in Riverton, Gimli, and Grand Beach are also protected by dykes but these embankments can be considered as permanent structures due to the nature and supervision of their construction. For this reason urban damages in the event of dyke failures are not considered in this study; only the agriculturally related land damages in the event of temporary dyke failures and damage to the dyking system itself have been investigated in this study.

STUDY AREA

The study area comprises those agricultural foreshore areas below elevation 722 around the southern portion of Lake Winnipeg which are protected by the existing temporary dyking system.

A statistical summary of the dykes and the areas protected is given in Table 1. Location maps, typical cross sections, and top-of-dyke profiles are provided in Figures 10 to 22.

BACKGROUND

The Temporary Dyking System

During the summer of 1966, the Water Resources Branch constructed temporary dykes in the Libau, Netley, and Riverton areas in anticipation of high water levels on Lake Winnipeg. The dykes considerably reduced the extent of flooding in these areas as lake levels increased. On September 6, 1966, the level of Lake Winnipeg recorded at Gimli reached an elevation of 719.8 which is the highest water level attained during the period of record which dates back to 1913.

The dykes are considered to be of a temporary nature as they were mainly constructed using draglines with little or no control as to selection and compaction of material. Protection of the side slopes from wave action has not been provided for on most of the dyking system. The base of the dykes is between elevation 716 and 718 with an average embankment height of 5 to 6 feet. The top width of the dykes varies from eight to fifteen feet. Interior drainage has been provided for by use of gated culverts, extending dykes up drainage channels to the 722 foot contour, where feasible, or by use of portable pumping units.

The temporary dyking system around the southern basin of Lake Winnipeg affords protection to about 19,000 acres of land which are below elevation 722. The length of the dyking system, including the Libau Area line of defense, totals about 50 miles of embankment in various locations around the southern periphery of the Lake.

Land Acquisition Program

In 1970, a land acquisition program was initiated by the Province with the purpose of purchasing privately owned agricultural land unprotected by the temporary dyking system. The land purchased is administered under the Crown Lands Act and is utilized for hay land and wildlife purposes. As a result of this program, the majority of land, in the Riverton-Washow Bay and Libau Areas, on the lake-side of the dykes, is now owned by the Crown.

Permanent Dyking

In a preliminary study[1], subsequent to the flood stages experienced on Lake Winnipeg in 1966, the Water Resources Branch submitted requirements for a permanent dyking system to protect low lying agricultural land around the Lake. It was suggested that the dykes have a top elevation of 723, a 5:1 slope facing the Lake, a 3:1 slope on the land side and a 12 foot top width. In all areas the dykes would terminate at the intersection with the 722 foot contour. The elevation of the top of dyke was determined on the basis of the maximum recorded lake level of 719.8 observed at Gimli in September, 1966. To this elevation was added an allowance of 3.2 feet for wave uprush and freeboard. The estimated cost, in 1966, of permanent dyking and interior drainage in the Libau, Netley and Riverton-Washow Bay areas including 15% for contingencies and 15% for engineering totalled about $2,000,000. Due to the difficulty in trying to evaluate the cost saving which would be realized by the existence of temporary dykes, it was felt that it would be preferable to make no allowance for this saving in the above mentioned cost estimate. Reshaping the side-slopes to 5:1 on the lakeside and 3:1 on the landside would allow some portions of the dykes constructed during 1966 to be used as permanent dykes while other portions would have to be completely rebuilt. To determine more accurate estimates would necessitate an extensive material sampling program on the existing dyking system.

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[1] Water Resources Branch, December, 1966
Preliminary Study of Measures for Flood Control and Shoreline Protection on Lake Winnipeg

Surveys

During the summer of 1972, a survey of the temporary dyking system was undertaken by personnel of the Water Resources Branch. The surveys obtained information concerning the location, profile and typical cross-sections of the dyking system.

DYKE DAMAGES

The Stage-Damage Relationship for Dyke Damages

After a study of the costs of pumping, dyke construction and maintenance over the past five years, the Water Resources Branch constructed a stage-damage curve reflecting these costs for Lake Winnipeg. The data showed that with an average lake elevation of 716 annual dyke damages are in the order of $30,000 and pumping costs $30,000. It was assumed there would be no dyke damage at elevation 710 and no pumping required at elevation 715. These figures were prorated to construct the stage-damage curve for dyke damage and pumping costs.

When pumping costs are deleted from the above costs, there is a linear relationship between average lake stages and dyke maintenance. Assuming the relationship is near linear from elevation 716 to approximately 717.5 allows this stage-damage curve to be employed in computing the mean annual erosion damages to the dyking system due to the duration of high lake levels. A comparison of damages computed for both natural and regulated conditions provides an evaluation as to the effect of the proposed regulation on dyke maintenance costs.

The Stage-Duration Relationships

The percent of time that lake levels are below a particular elevation can be expressed in the form of a stage-duration curve. Two stage-duration curves are utilized in this report in computations to compare damages to the dykes due to the duration of high lake levels under natural and regulated conditions.

The curve shown in Figure 8 was constructed from mean monthly water level data recorded during the years 1928 to 1966 for the open water months May to November.

The curve shown in Figure 9 was constructed from data made available by Manitoba Hydro for development sequence G1JA-Iter. 3, for the open water months June to November of the 1981 load year. It is assumed the duration curve for the 1981 load year represents an average for the anticipated regulated conditions on Lake Winnipeg.

The Duration-Damage Relationships

A duration-damage curve relates damage values to the percent of time they are exceeded. Using this relationship a mean annual damage can be computed. Duration-damage curves were constructed for both natural and anticipated regulated conditions on the Lake by combining the stage-damage curve for dyke damages and the previously discussed duration curves.

For natural conditions mean annual dyke damages were computed to be $16,800 and for regulated conditons mean annual dyke damages were computed to be $19,400.

Effects of Regulation on Dyke Maintenance

From comparison of the duration-damage relationships utilized to determine the effects of regulation on dyke maintenance costs it appears that due to increased mean water levels annual costs will be some $2,600 higher under regulated conditions than the computed mean annual dyke damages of $16,800 for the natural state of the Lake.

Pumping Costs

Pumping costs on an annual basis for natural conditions are $4,700 compared to $1,600 for regulated conditions, and thus regulation will decrease these costs by about a third. When pumping costs are included with dyke maintenance costs in a duration relationship, annual costs for natural conditions and regulated conditions are $21,500 and $21,000 respectively.

DYKE FAILURE

Observed Dyke Failures

On two occasions high lake levels have caused failure to portions of the temporary dyking system. In September, 1966 the Ducks Unlimited Dyke was overtopped during which time the miximum daily lake level recorded at Gimli reached an elevation of 719.8. The top of the dyke was at about elevation 720.5 when the failure was observed; subsequent to this occurrence the embankment has been raised. The other failure was observed on a portion of the Petersfield Dyke where the embankment material had settled excessively so that the top of the dyke was only at about elevation 720. The failure was due to overtopping in June of 1970 while the daily water level recorded at Gimli was of the order of elevation 718.5. This dyke has also been raised. Both of these failures occurred at the southern end of the Lake where the increase of lake levels due to wind effects would be at a maximum.

Other failures of the embankment have been observed in the form of local bank sloughing due to natural springs or drainage channels in the vicinity of the dykes and wave action on the face of some lengths of the dyking system. Where roads serve as dykes, failures due to traffic loads have been reported in some locations. These latter mentioned failures have not led to any damages to the protected acreage. No failures due to the burrowing of muskrats has been observed, although this type of damage has been reported on the Petersfield Dyke and along the two mile stretch of dyke north of the Town of Riverton.

Risk of Dyke Failure

The probability of failure of the dykes associated with different still water elevations has been determined by using what is termed as the "Freeboard Approach". Adequate maintenance is assumed and only the risk associated with failure due to overtopping is determined. Inundation due to continued erosion with no maintenance or failure of an interior drainage facility is not considered in this analysis nor is allowance made for the condition of the embankment.

Basically, the method consists of subtracting a freeboard allowance for wave uprush from the top of dyke elevation and assuming a 100% probability of failure is associated with that elevation. In this case the top of dyke is assumed to be elevation 723 and the freeboard allowance three feet. The probability associated with failure at lower still water stages is then equal to the probability of a wind set-up on the Lake of sufficent magnitude such that the still water stage plus set-up equals the top of dyke elevation minus the freeboard allowance.

Using data on wind set-up on Lake Winnipeg prepared by the Water Resources Branch the probabilities of failure associated with still water stages were calculated and are summarized below:

Still Water Elevation	Probability of Overtopping based on Lake Winnipeg Wind Set-up
716	0.1%
717	0.5%
718	2%
718.5	4%
719	9%
719.5	23%
720	100%

Based on this approach, when the still water elevation is within 715 to 716, which is the upper end of the proposed range of regulation, the probability of the dykes being overtopped is reduced due to regulation.

The Stage-Frequency Relationships

A stage-frequency curve relates lake stages and their probabilities of occurrence. The two stage-frequency curves presented in this report are used in computations to compare damages to agricultural land under natural and regulated conditions assuming dyke failure occurs and to compare the probability of this occurrence under both conditions.

The first of these curves is shown in Figure 6 and relates maximum annual daily levels in feet to their probability of occurrence under natural conditions. This curve was prepared from data recorded at Winnipeg Beach during the years 1929 to 1966.

The relationship shown in Figure 7 relates maximum regulated annual daily levels in feet to their probability of occurrence. This curve for regulated conditions was prepared from data made available by Manitoba Hydro for a period corresponding to the natural data and for development sequence G1JA-Iter. 3. This development sequence assumes a diversion capacity from the Churchill River of 30,000 cfs. by 1975 and Lake Winnipeg Regulation between elevations 711 and 715 by 1974.

Both relationships, Figure 6 and Figure 7, include wind set-up on the Lake.

Effects of Regulation on Dyke Failures

A comparison of Figures 6 and 7, showing maximum annual daily lake levels versus probability for natural and regulated conditions respectively, indicates that under regulated conditions a level below elevation 719 has a greater probability of occurrence and lake levels above elevation 719 have a smaller probability of occurrence than is the case for natural conditions. If it is considered the dykes would fail at an elevation below 719 then regulation would be considered as being detrimental.

If it is considered the dykes would fail at an elevation exceeding 719 then regulation could be considered as beneficial to the protection of the land behind the dykes. From the previous discussion on dyke failures it can be assumed, provided adequate maintenance is carried out, regulation will enhance the protection of land behind the dykes.

The determination of a precise probability for the failure event is difficult when considering the temporary dyking system as a whole. The frequency relationships utilized in this analysis reflect conditions at one particular location on the periphery of the southern pool of the Lake, which would have the maximum wind and wave action, and due to the nature of the wind effects on Lake Winnipeg, applying this data to other locations is an approximation, but would also be on the conservative side. High lake stages at the extreme southern end of the Lake have a higher probability of occurrence than similar stages further north on the southern pool of the Lake. Also varying as to location is the condition of the embankment and its proximity to the Lake itself. On the lakeside of much of the dyking system are long stretches of gradually sloping land covered with marsh vegetation or grass that would significantly reduce wave heights and wave uprush on the dykes during storms. Some sections of the dykes are immediately adjacent to the shore and are continually eroded by wave action.

USE OF PROTECTED ACREAGE

Land Use

Information pertaining to present land use in the vicinity of the dykes was obtained from maps prepared by Canada Land Inventory. Also obtained from Canada Land Inventory were land values and the estimated net annual incomes used in this report. A summary of these values by land use classification is presented in Table 2.

TABLE 2

Values of Land and Annual Income by Land Use

Type of Land Use	Land Value Range (per acre)	Estimated Net Annual Income (per acre)
Cropland	$80 - $100	$15
Improved Pasture	$20 - $ 35	$ 8
Native Grazing	$10 - $ 20	$ 4
Woodlot Pasture	$10	$ 2

Utilizing contour information from Lake Winnipeg Area Contour Mapping prepared in 1967 by the Surveys Branch and the information on land use, the total acreage protected to the 722 foot contour elevation by different segments of the dyking system was estimated and broken down by land use classifications. Using the previously mentioned estimates of net annual income a total estimated net annual income was calculated for the land protected by the temporary dyking system. These totals and acreages by land use classification as well as the acreage protected between various contour elevations to 722 are presented in Table 1.

Flood Damages to Agricultural Land

There are a number of variables involved in the determination of flood damages to agricultural land. Broadly, these factors include the time of year of inundation, the duration of high water levels and the intended use of the acreage flooded. For the purposes of this study it was assumed a reasonable estimate of damage due to inundation is the amount of income that the land would generate in one year. These values are presented in Table 2 as estimated net annual incomes. A short duration of flood levels, one day or less, is considered sufficent to cause this amount of damage to the agricultural land. Once inundated, it is felt the water would lay on the land for a sufficient time to delay seeding or harvesting, reduce the quality of the crops or prevent use of the land as pasture because the remaining embankments would impede interior drainage.

A Stage-Damage Relationship for Damages to Agricultural Land

A stage-damage curve relates damages which would occur, due to flooding at a particular water surface elevation.

In the computation of flood damages to agricultural land, when failure of the dyke is assumed to have occurred, all that segment of land below the prevailing daily lake level is considered inundated and the damages to the land computed. Damages are computed for a number of elevations. A smooth curve drawn through the computed values represents the assumed damage due to the failure of the temporary dykes at various water surface elevations. This stage-damage curve is presented as Figure 3 of this report. By assuming all segments of the dyking system fail simultaneously this relationship represents a "worst case" although dyke failures are generally localized occurrences.

Utilization of this "worst case" analysis will result in a maximum average annual damage to the protected agricultural land and, hence, reflect a maximum average annual benefit that could be realized from the dyking system.

Comparison of Frequency-Damage Relationships

A frequency-damage curve relates damages to their probabilities of occurrence. This relationship is constructed by combining a stage-frequency curve and a stage-damage curve. The average annual damage is equal to the area under a frequency-damage curve. Frequency-damage curves were constructed for both regulated conditions (Figure 4) and natural (Figure 5) using the stage-damage curve for damages to agricultural land and average annual damages were computed for a number of cases.

The first case assumes the dyking system offers no protection at all to the agricultural land. For this case under natural conditions the average annual damages were calculated as $7,600 and under regulated conditions as $14,900.

The second case assumes the dyking system affords protection to elevation 719. For both natural and regulated conditions, this water surface elevation has a probability of occurrence of about 2% or, stated differently, a lake level with a return period of about 50 years. For this case, under both natural and regulated conditions, the average annual damages to the agricultural land were calculated to be about $1,900.

The third case assumes the dykes afford protection against flood levels with a probability of occurrence of 1%, or the flood with a return period of 100 years. In both natural and regulated states this lake level is at about elevation 719.5. For this case under natural conditions the average annual damages to agricultural land were calculated as $1,100 and under regulated conditions as $1,075.

The fourth case assumes the dyking system affords protection to an elevation of 720. This water surface elevation has a probability of occurrence under natural conditions of about 0.5% and under regulated conditions of about 0.3%. Under natural conditions the average annual damages to agricultural land were calculated as $575 and under regulated conditions as $345.

Although dyke failures are generally localized occurrences it is useful in an analysis of the effects of regulation to consider the "worst case" discussed previously in this section. This "worst case" assumes all segments of the dyking system fail at the same lake stages and for the purposes of determining average annual agricultural land damages provides an idea of the magnitude of these damages and also the difference in these damages between natural and regulated conditions. The cases for which the computations of average annual damages to dyke protected agricultural land were carried out and the computed values for natural and anticipated regulated conditions are summarized as follows:

Case 1: Assumes dyking system offers no protection
Average Annual Damages

Natural Conditions	$ 7,600
Regulated Conditions	$14,900

Case 2: Assumes dykes afford protection to elevation 719
Average Annual Damages

Natural Conditions	$ 1,900
Regulated Conditions	$ 1,900

Case 3: Assumes dykes afford protection to elevation 719.5
Average Annual Damages

Natural Conditions	$ 1,100
Regulated Conditions	$ 1,075

Case 4: Assumes dykes afford protection to elevation 720
Average Annual Damages

Natural Conditions	$ 575
Regulated Conditions	$ 345

Although the regulation of Lake Winnipeg as proposed decreases the average probabilities of dyke failures by a small amount, the decreases in average annual damages, to agricultural land protected by the dykes, due to regulation, can be considered as being negligible. If the dykes were not in existence, damages to agricultural foreshore lands below elevation 719 would be greater under the proposed pattern of regulation than under natural conditions.

OBSERVATIONS AND CONCLUSIONS

Measures which could be implemented to enhance the protection afforded by the temporary dyking system and to reduce the damage to the dykes by increased mean water levels include: trimming the side slopes on some lengths of the dykes and providing vegetation cover or rip-rap to alleviate erosion of the lakeside slopes; providing improved facilities for interior drainage; and rebuilding certain lengths of dyke considered as inadequate.

Improved side-slopes and side-slope protection should be considered for sections adjacent to the Lake where extensive erosion damage due to wave action has been noticed in the past. One such section is the length of dyke along Ferry Road north of Riverton and another is in the Town of Riverton where the dykes are eroded by the waves from passing boats and float-equipped aircraft. Another section is the length of dyke on the road allowance north of Section 29 Township 15 Range 6E in the Libau Area.

Before a decision could be made regarding reconstruction of the dyking system or the rebuilding of certain sections, such as those immediately adjacent to the Lake, an extensive embankment material sampling program would be necessary for the determination of accurate cost estimates of such measures.

As stated previously, a cost estimate for a permanent dyking system in 1966 was in the order of $2,000,000. The top of dyke elevation was 723 which includes three feet of freeboard.

Without making any adjustments for price increases average annual costs for a dyking system of $2,000,000 at an interest and amortization rate of 7% for 50 years would amount to $145,000. Average annual damages of $15,000 would be considered a benefit if a permanent dyke offers protection against these losses. Therefore the benefit-cost ratio for this permanent dyking system would be approximately 0.1 which means that for every dollar spent on flood control works there would be a return of ten cents in benefits which would indicate that permanent dyking cannot be justified on an economic basis.

It would appear that for an average annual benefit of $15,000 and not considering annual maintenance and the original cost of the temporary dyking system, the most that could be spent to improve the performance of these temporary dykes would be about $200,000.

It is concluded from this investigation that the regulation of Lake Winnipeg between elevations 711 - 715 will increase the cost of annual maintenance to the temporary dyking system by about $2,600 per year, but will decrease pumping costs by about $3,100. Regulation will also decrease the risk of dyke failure from over-topping. As an extreme case, if it is assumed that the temporary dykes do not offer protection to the agricultural land, the proposed regulation will increase agricultural damage by $7,000 per year.

TABLE I

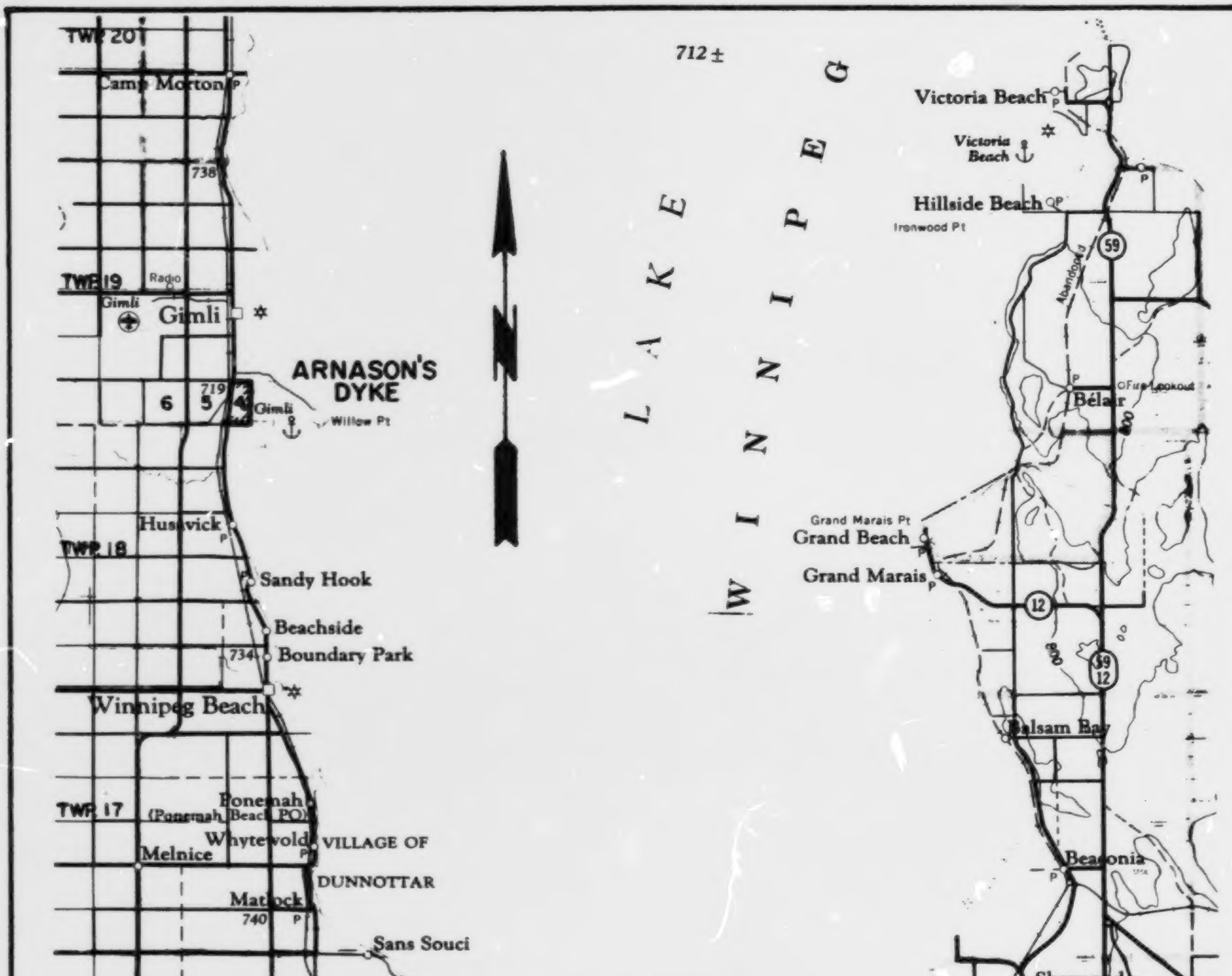
LAKE WINNIPEG TEMPORARY DYKING SYSTEM

SUMMARY TABLE

LOCATION	APPROXIMATE TOP OF DYKE ELEV. (G. S. OF C.) (FT.)	APPROXIMATE LENGTH OF DYKE (MILES)	TOTAL ACREAGE PROTECTED TO 722' (ACRES)	ACREAGE PROTECTED (ACRES)			CROPLAND (ACRES)	IMPROVED PASTURE (ACRES)	NATIVE GRAZING (ACRES)	WOODLOT PASTURE (ACRES)	LAND VALUE RANGE		ESTIMATED NET ANNUAL INCOME ($)
				ELEV. 716' TO 718'	ELEV. 718' TO 720'	ELEV. 720' TO 722'					LOW ($)	HIGH ($)	
WASHOW BAY AREA	722-3	7.5	2,740	500	1,510	730	1,070	660	550	460	108,800	145,700	24,500
RIVERTON AND NORTH AREA	722-3	16.9	12,360	1,970	5,710	4,680	5,800	2,220	880	3,460	551,800	709,800	115,200
ARNASON'S DYKE	723	2.7	① 510	330	130	50	20	50	330	10	6,000	10,450	2,040
PETERSFIELD	723	3.5	880	420	250	210	440	180	170	90	41,400	54,600	8,900
LIBAU AREA	720-1	② 15.5	1,710	240	600	870	720	530	260	200	72,700	97,720	16,480
DUCKS UNLIMITED DYKE AND P.R. 320	723 & 721	③ 3.7	1,110	600	510	④ —	290	150	400	270	32,900	44,950	7,690
TOTALS		49.8	19,310	4,060	8,710	6,540	8,340	3,790	2,590	4,490	813,600	1,063,220	174,810

NOTE:

1. INCLUDES A 100 ACRE SEWAGE TREATMENT FACILITY.
2. TOTAL LINE OF DEFENSE ALONG ROAD ALLOWANCES.
3. INCLUDES 0.6 MILES OF P. R. 320 CONSIDERED AS DYKE.
4. INFORMATION NOT AVAILABLE.


TWP 20
712 ±
LAKE WINNIPEG
Camp Morton
738
Victoria Beach
Victoria Beach
Hillside Beach
Ironwood Pt
59
Abandoned
TWP 19
Radio
Gimli
Gimli
ARNASON'S DYKE
6
5
719
4
Gimli
Willow Pt
Bélair
Fire Lookout
800
Husavick
TWP 18
Sandy Hook
Beachside
734
Boundary Park
Winnipeg Beach
Grand Marais Pt
Grand Beach
Grand Marais
12
59
12
Balsam Bay
TWP 17
Ponemah
(Ponemah Beach PO)
Whytewold
VILLAGE OF DUNNOTTAR
Melnice
Matlock
740
Sans Souci
Beaconia
Sherwood
8
TWP 16
Netley
Netley
9
NETLEY MARSH
Netley Lake
Scanterbury
BROKENHEAD INDIAN RESERVE 4
5
4
3
2
31
32
LIBAU AREA DYKES
30
29
19
20
18
17
Libau
7
8
59
6
5
31
PETERSFIELD DYKE
36
Petersfield
25
22
23
24
TWP 15
DUCKS UNLIMITED DYKE
7
6
2
1
Creek
Clandeboye
PARISH OF ST. PETER
Peguis
PARISH OF ST. PETER
Dencross
Brokenhead
12
738
745
Ridgely
TWP 14
RGE 4E
RGE 5E
RGE 6E
Walkleyburg
RGE 7E

PROVINCE OF MANITOBA

DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

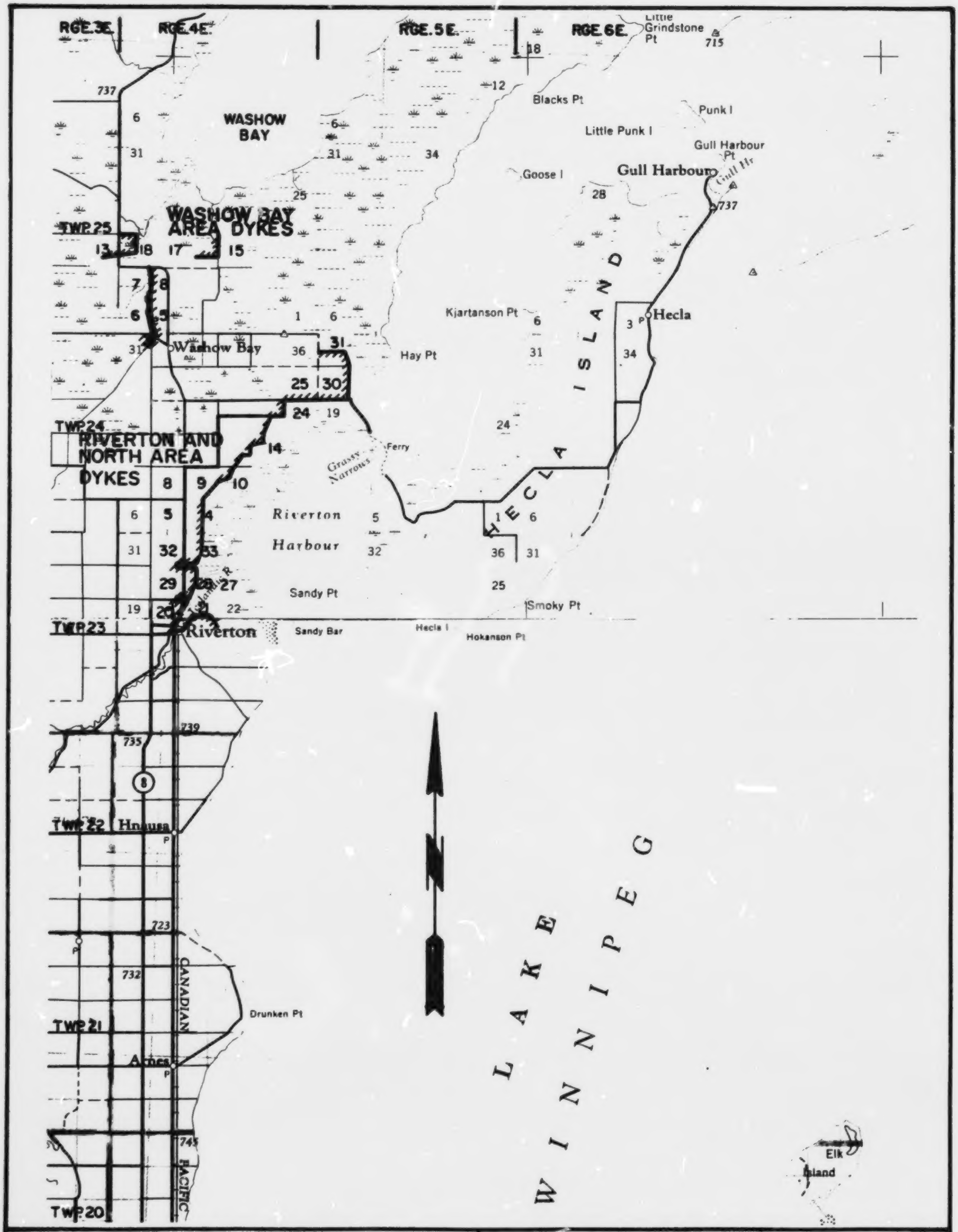
LOCATION MAP NO. 1

LAKE WINNIPEG
TEMPORARY DYKING SYSTEM

PREPARED P.G.	DRAWN P.G.	SUBMITTED	APPROVED
	CHECKED	DATE	DATE

SCALE 1"=4 MI.	DATE MAR./74	SHEET 1 OF 22	FILE NO. 39-2-1233

FIGURE 1


RGE.3E.
RGE.4E.
RGE.5E.
RGE.6E.
Little Grindstone Pt
715
737
WASHOW BAY
WASHOW BAY AREA DYKES
TWP.25
Washow Bay
Blacks Pt
Punk I
Little Punk I
Gull Harbour Pt
Gull Harbour
Goose I
HECLA ISLAND
Hecla
Kjartanson Pt
Hay Pt
Grassy Narrows
Ferry
TWP.24
RIVERTON AND NORTH AREA DYKES
Riverton Harbour
Sandy Pt
Smoky Pt
TWP.23
Riverton
Sandy Bar
Hecla I
Hokanson Pt
739
735
8
TWP.22
Hnausa
723
732
CANADIAN PACIFIC
Drunken Pt
TWP.21
Arnes
745
TWP.20
LAKE WINNIPEG
Elk Island

PROVINCE OF MANITOBA

DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

WATER RESOURCES BRANCH

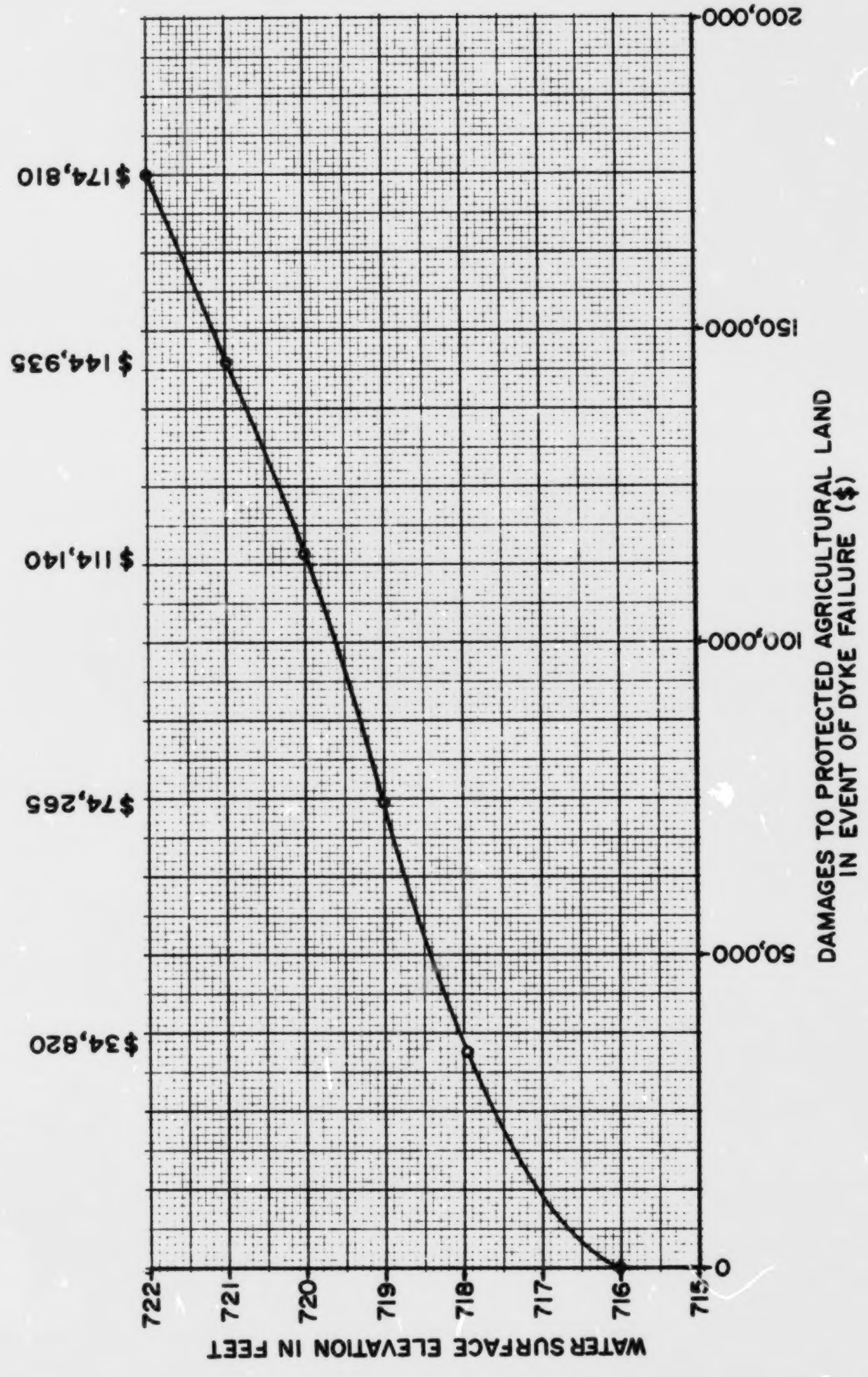
CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

LOCATION MAP NO.2

LAKE WINNIPEG TEMPORARY DYKING SYSTEM

PREPARED	DRAWN	SUBMITTED	APPROVED	SCALE	DATE	SHEET	FILE NO.
P.G.	P. G.			1"=4 MI.	MAR./74	2 OF 22	39-2-1233
	CHECKED	DATE	DATE				

FIGURE 2



PROVINCE OF MANITOBA

DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

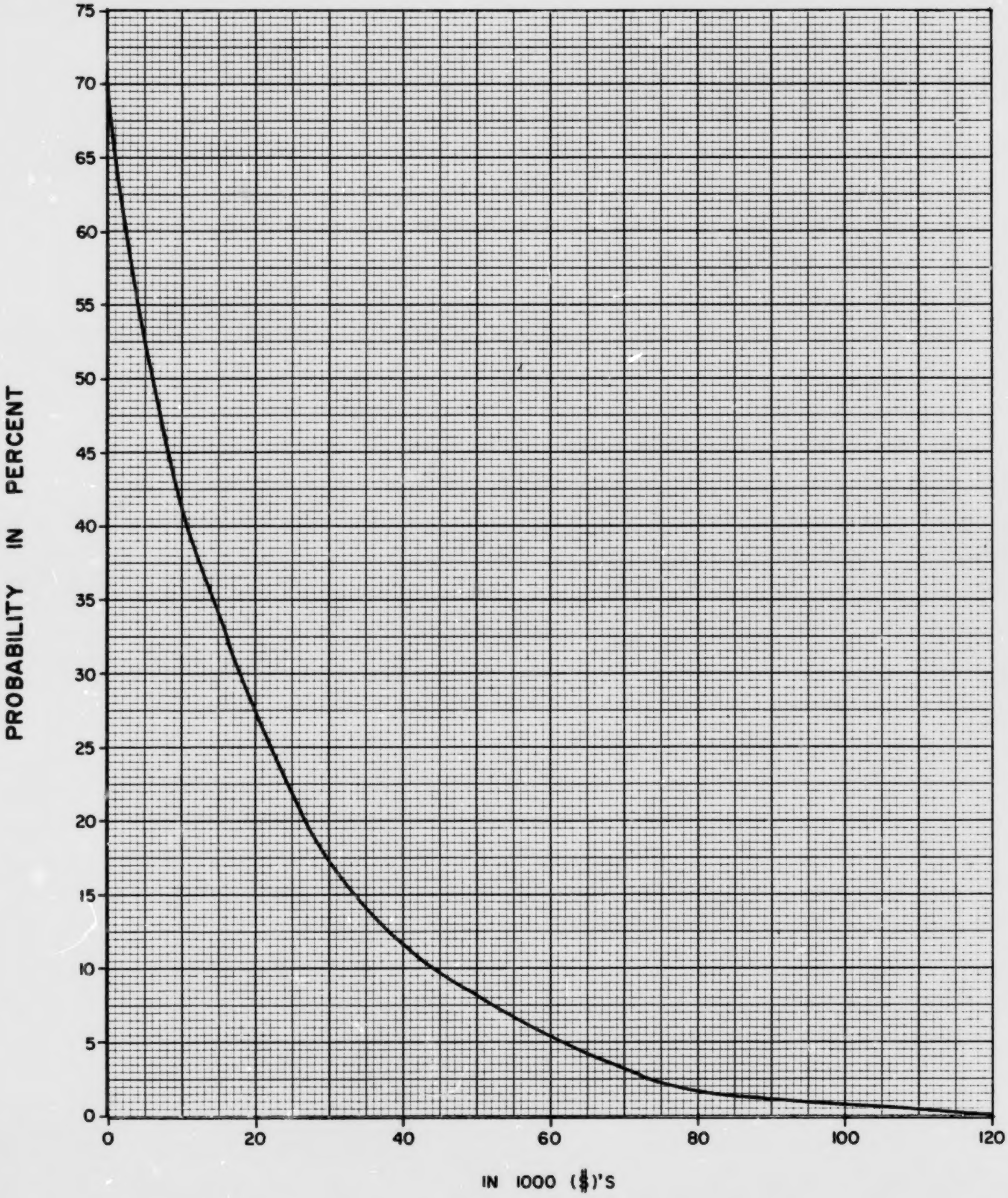
WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

STAGE DAMAGE CURVE
PROTECTED AGRICULTURAL LAND

PREPARED	DRAWN	SUBMITTED	APPROVED	SCALE	DATE	SHEET	FILE NO.
R.Z.	P.G.			AS SHOWN	MAR./74	3 OF 22	39-2-1233
	CHECKED	DATE	DATE				

FIGURE 3



DAMAGES TO PROTECTED AGRICULTURAL LAND
IN EVENT OF DYKE FAILURE

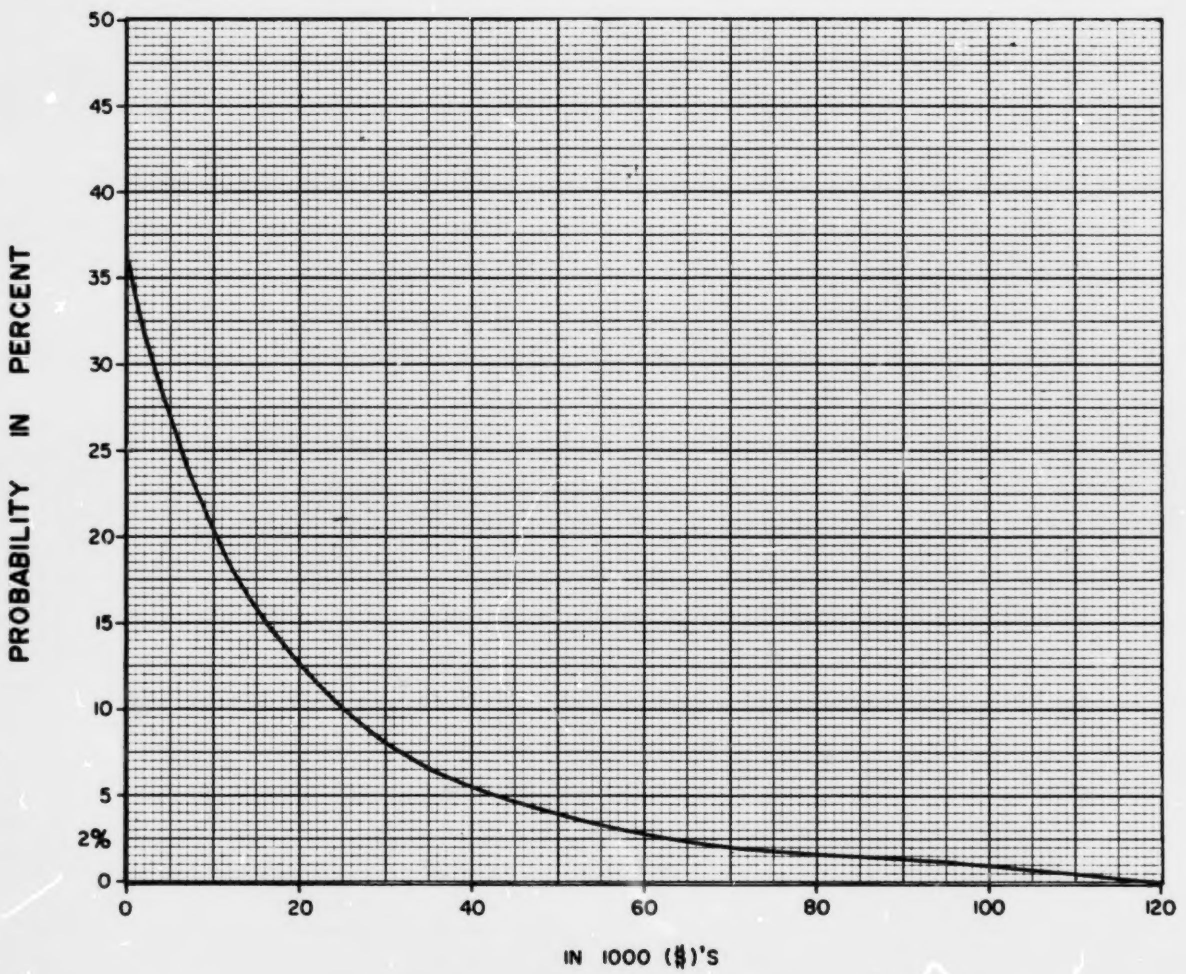
PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

FREQUENCY DAMAGE CURVE
REGULATED CONDITIONS
PROTECTED AGRICULTURAL LAND

PREPARED	DRAWN R.P.	SUBMITTED	APPROVED J. Mudry	SCALE AS SHOWN	DATE MAR./74	SHEET 4 OF 22	FILE NO. 39-2-1233
	CHECKED	DATE	DATE				

FIGURE 4

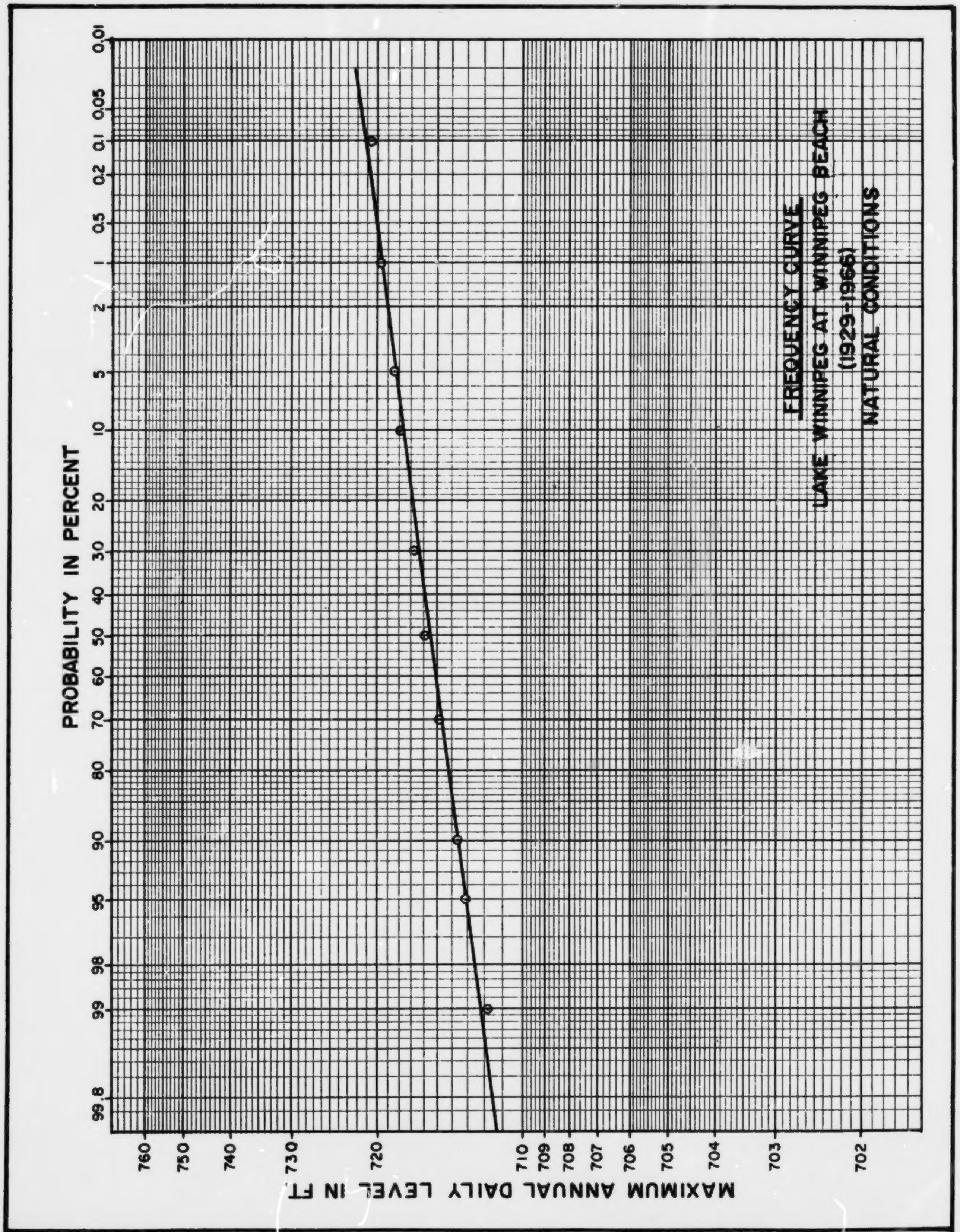


DAMAGES TO PROTECTED AGRICULTURAL LAND
IN EVENT OF DYKE FAILURE

PROVINCE OF MANITOBA DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT WATER RESOURCES BRANCH			
PREPARED	DRAWN R.P.	SUBMITTED	APPROVED
	CHECKED	DATE	DATE

CANADA-MANITOBA LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD			
FREQUENCY DAMAGE CURVE NATURAL CONDITIONS PROTECTED AGRICULTURAL LAND			
SCALE AS SHOWN	DATE MAR./74	SHEET 5 OF 22	FILE NO. 39-2-1233

FIGURE 5



PROVINCE OF MANITOBA

DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

WATER RESOURCES BRANCH

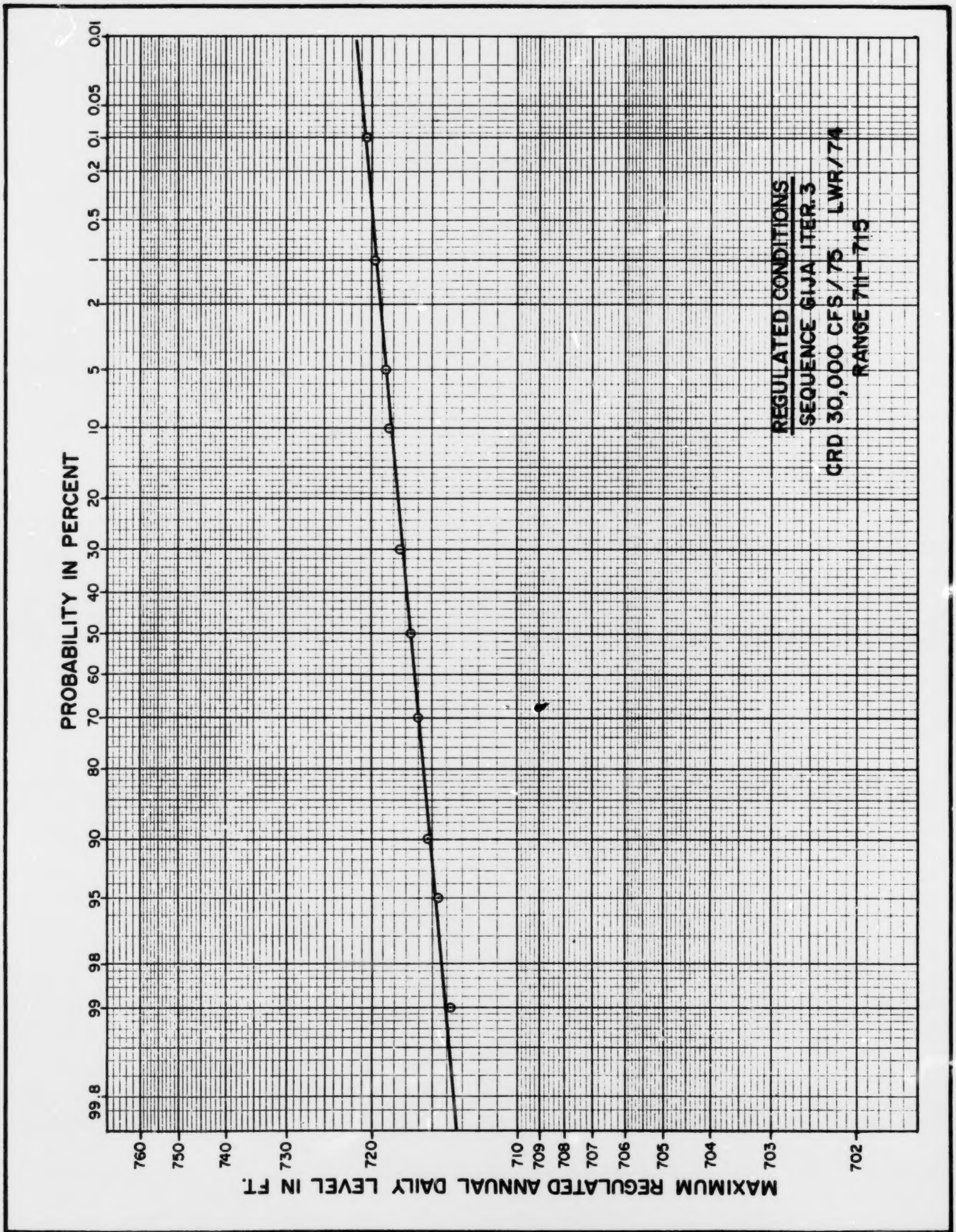
PREPARED	DRAWN P.G.	SUBMITTED	APPROVED
L. LEUNG	CHECKED	DATE	DATE

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

FREQUENCY CURVE
LAKE WINNIPEG
MAXIMUM ANNUAL DAILY NATURAL LEVELS

SCALE AS SHOWN	DATE MAR./74	SHEET 6 OF 22	FILE NO. 39-2-1233

FIGURE 6



PROVINCE OF MANITOBA

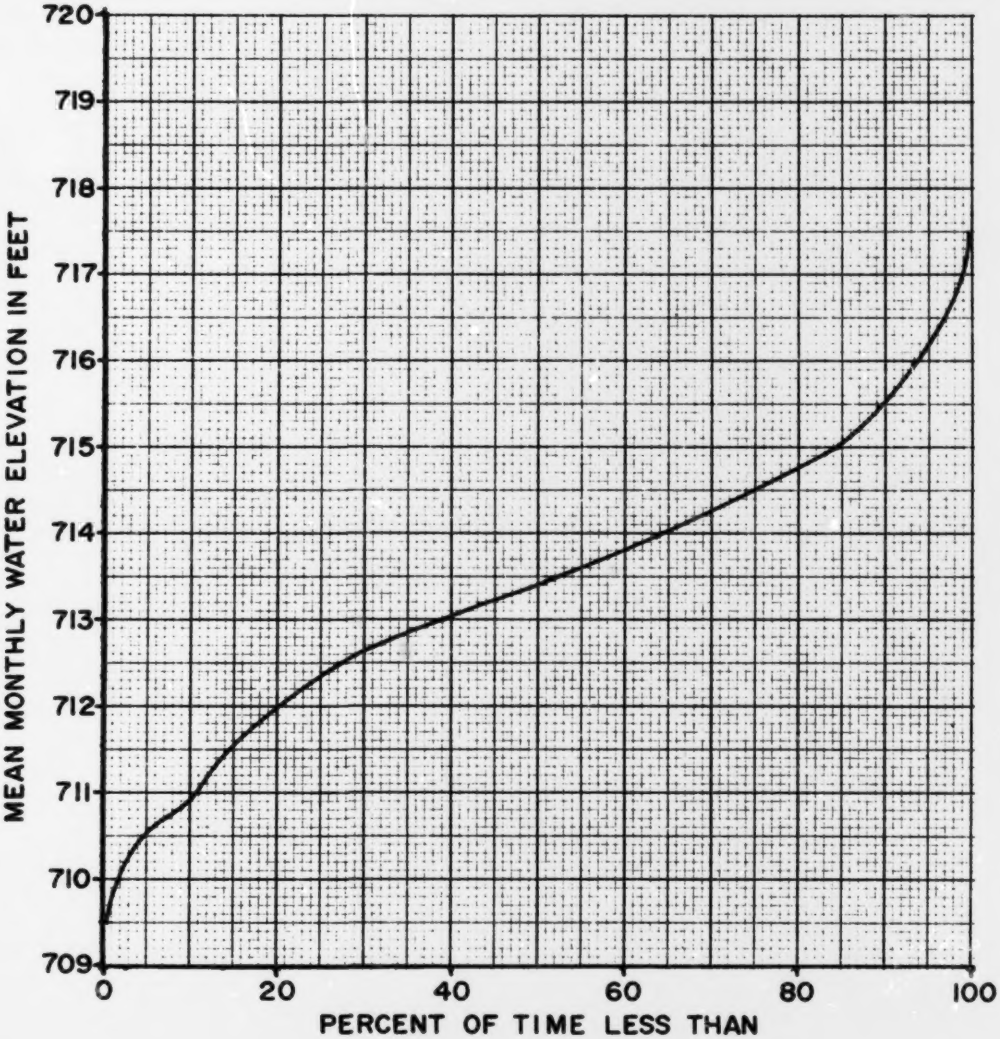
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

FREQUENCY CURVE
LAKE WINNIPEG
MAXIMUM ANNUAL DAILY REGULATED LEVELS

PREPARED L. LEUNG	DRAWN P.G.	SUBMITTED	APPROVED	SCALE AS SHOWN	DATE MAR./74	SHEET 7 OF 22	FILE NO. 39-2-1233
	CHECKED	DATE	DATE				

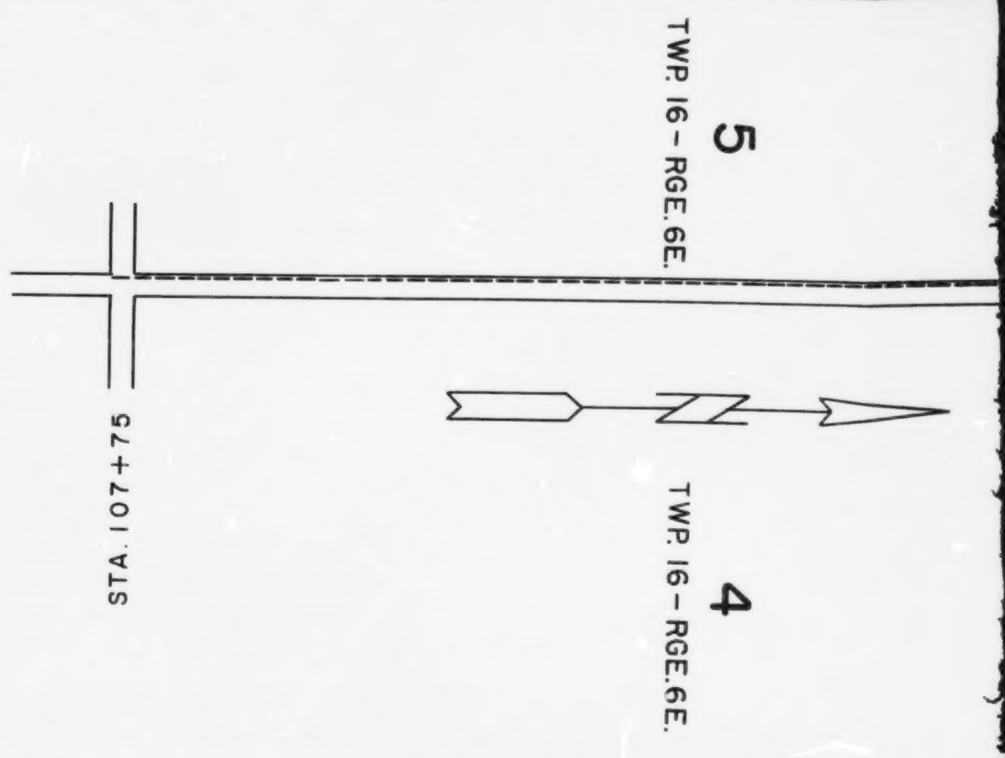


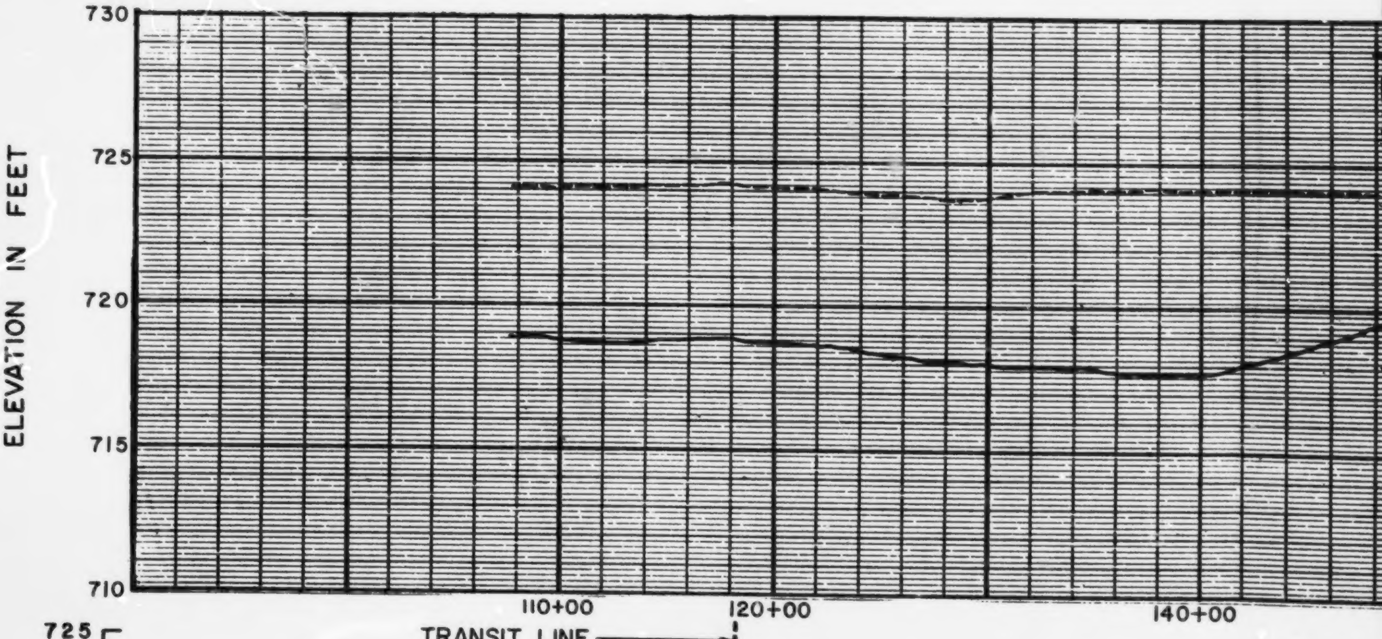
PERIOD: 1928-1966
MONTHS: MAY-NOVEMBER

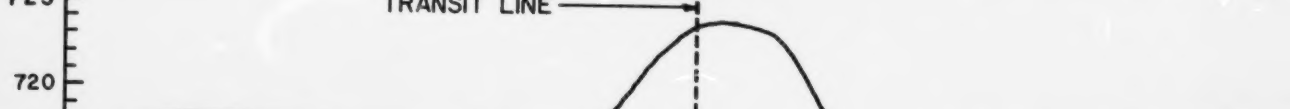
FROM: FILE NO. 39-3-1017
FIGURE NO. 6 PROGRAM FOR
REGULATION OF LAKE WINNIPEG.

PROVINCE OF MANITOBA DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT WATER RESOURCES BRANCH				CANADA - MANITOBA LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD STAGE-DURATION CURVE LAKE WINNIPEG RECORDED CONDITIONS				
PREPARED R.Z.	DRAWN P.G. CHECKED	SUBMITTED DATE	APPROVED DATE	SCALE AS SHOWN	DATE MAR./74	SHEET 8 OF 22	FILE NO. 39-2-1233	

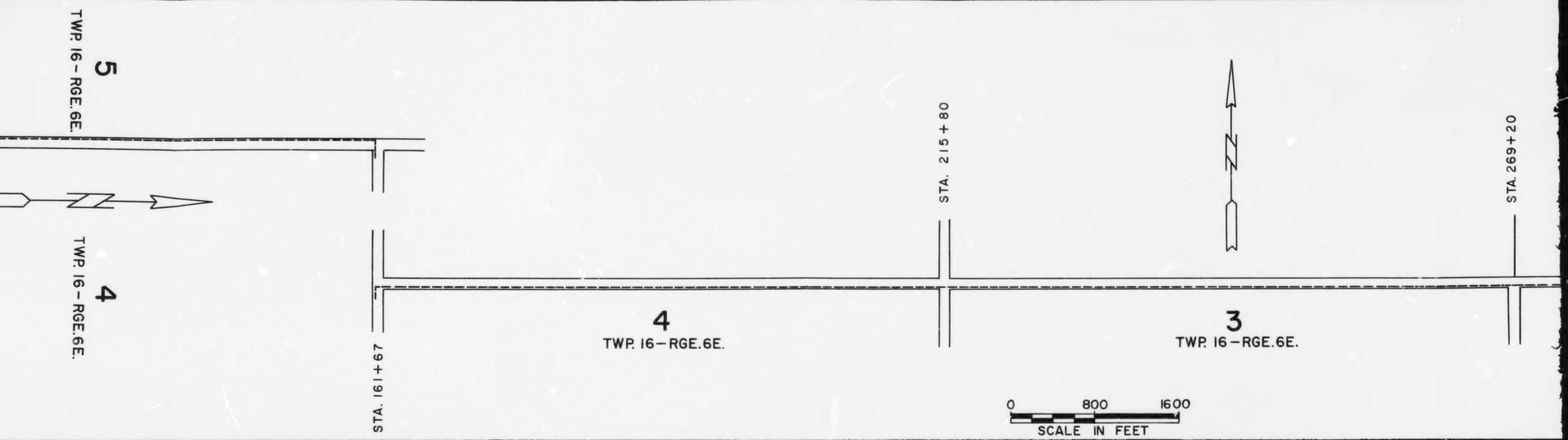
FIGURE 8

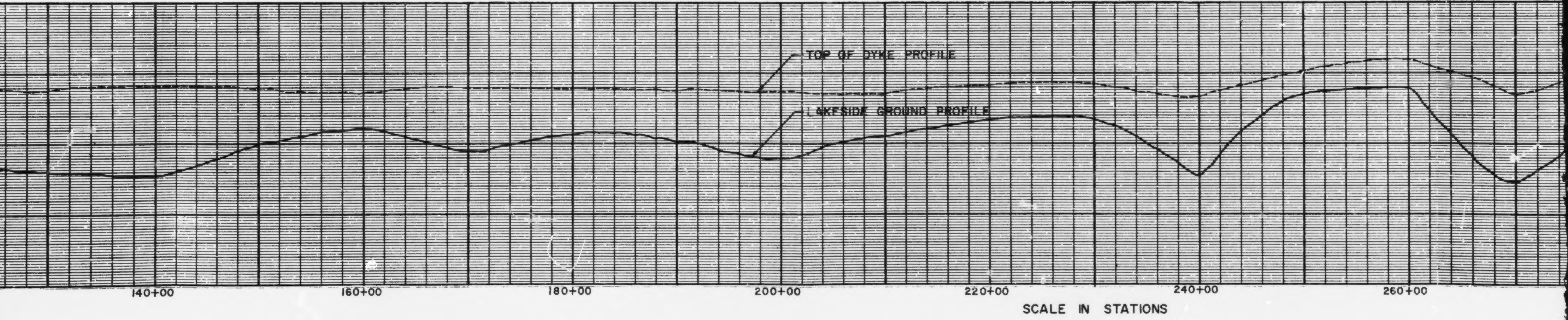

5
TWP. 16 - RGE. 6E.
STA. 107+75
4
TWP. 16 - RGE. 6E.

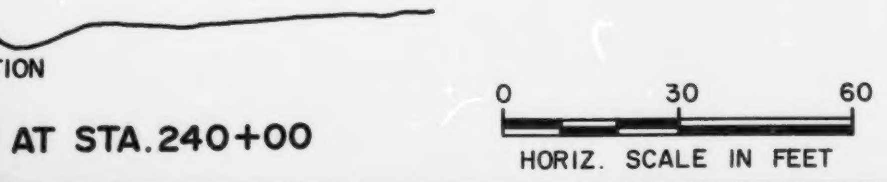




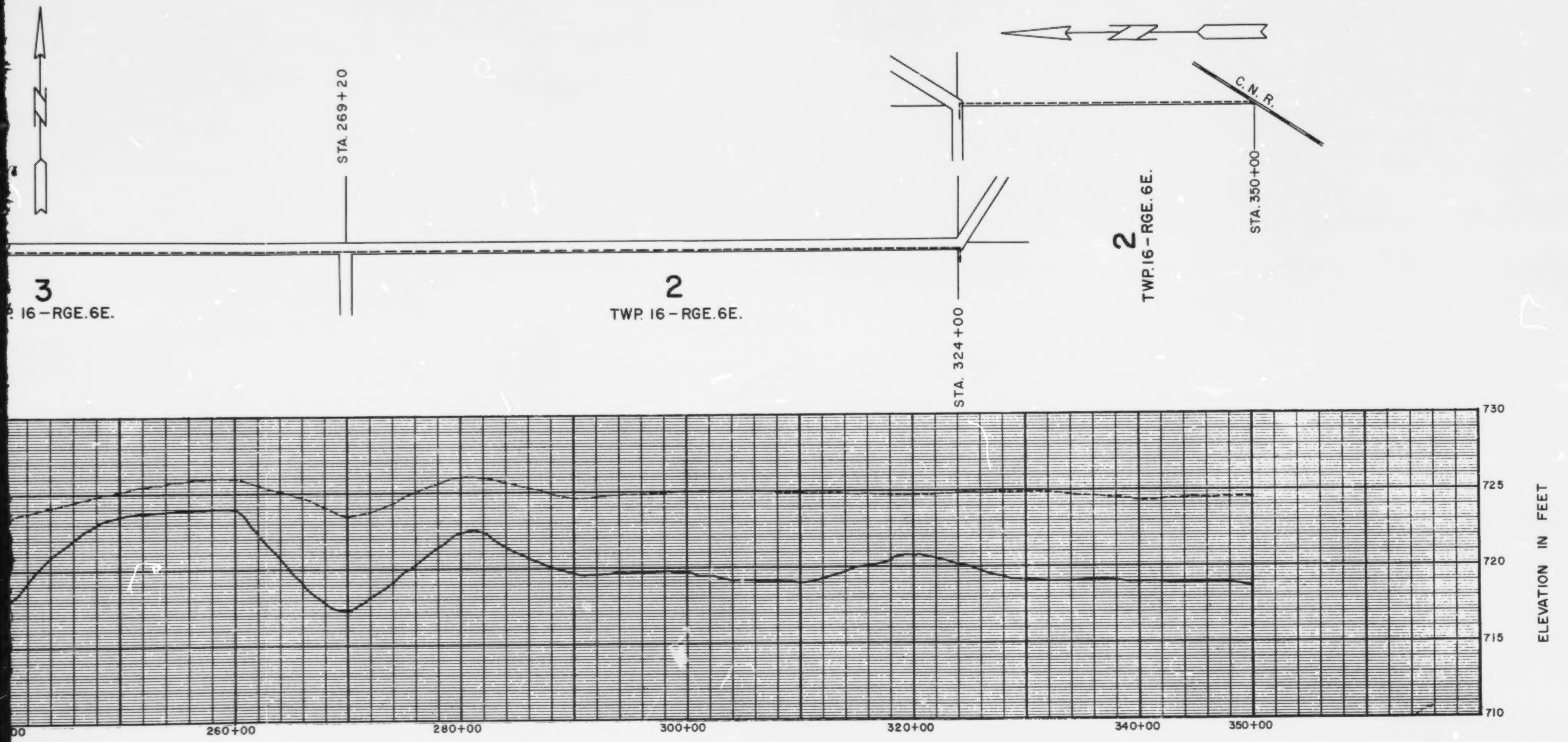
TYPICAL CROSS-SECTION TAKEN AT STA.240+00


5
TWP. 16 - RGE.6E.
4
TWP. 16 - RGE.6E.
STA. 161+67
4
TWP. 16-RGE.6E.
STA. 215+80
3
TWP. 16-RGE.6E.
STA. 269+20
0
800
1600
SCALE IN FEET


TOP OF DYKE PROFILE
LAKESIDE GROUND PROFILE
140+00
160+00
180+00
200+00
220+00
240+00
260+00
SCALE IN STATIONS


ION
0
30
60
HORIZ. SCALE IN FEET

AT STA.240+00


STA. 269+20
STA. 324+00
STA. 350+00
C.N.R.
3
16 - RGE. 6E.
2
TWP. 16 - RGE. 6E.
2
TWP. 16 - RGE. 6E.
730
725
720
715
710
ELEVATION IN FEET
00
260+00
280+00
300+00
320+00
340+00
350+00

FIELD BOOK 39-2-119L

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

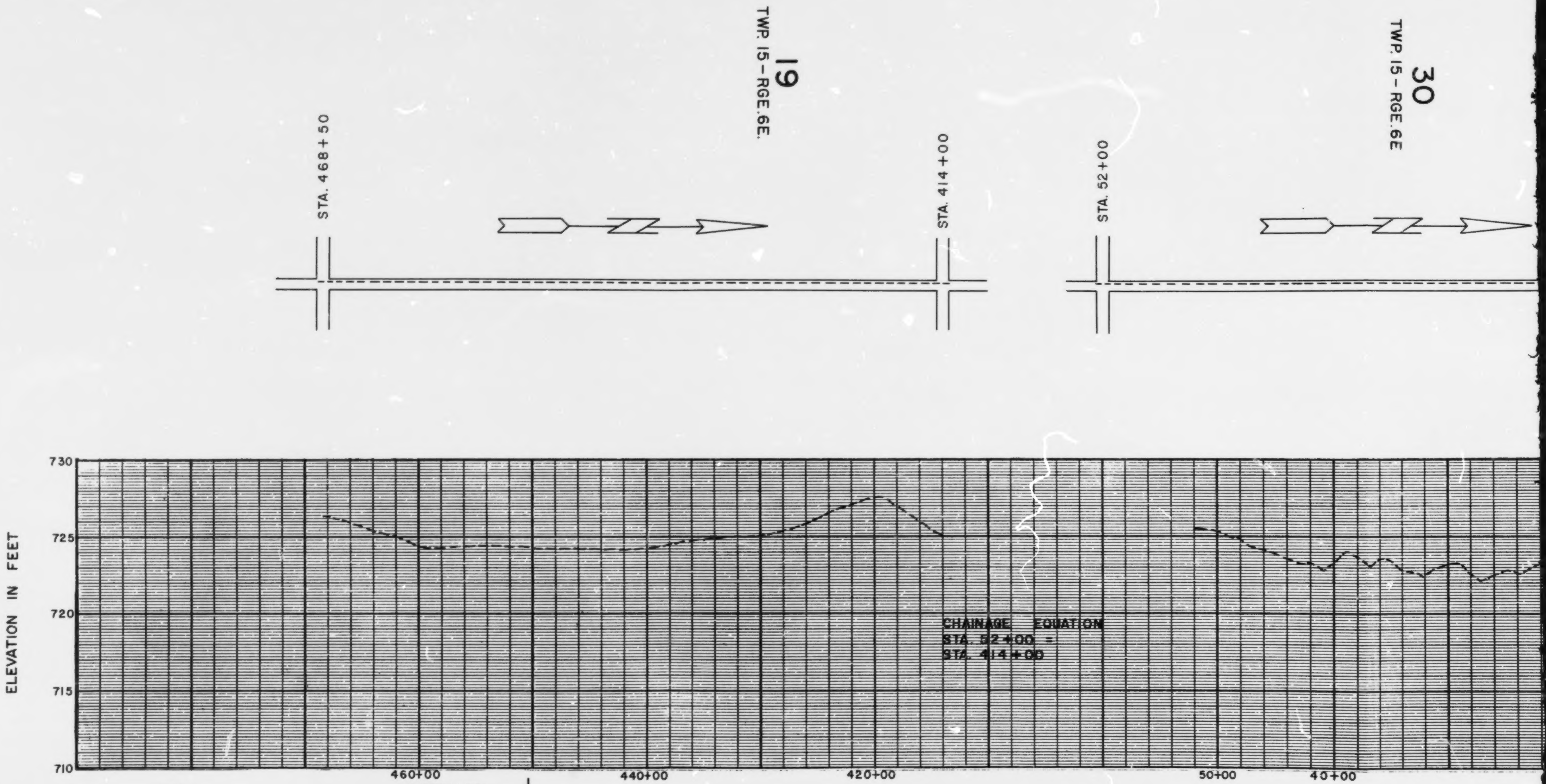
PREPARED	DRAWN T.M.	SUBMITTED	APPROVED
	CHECKED	DATE	DATE

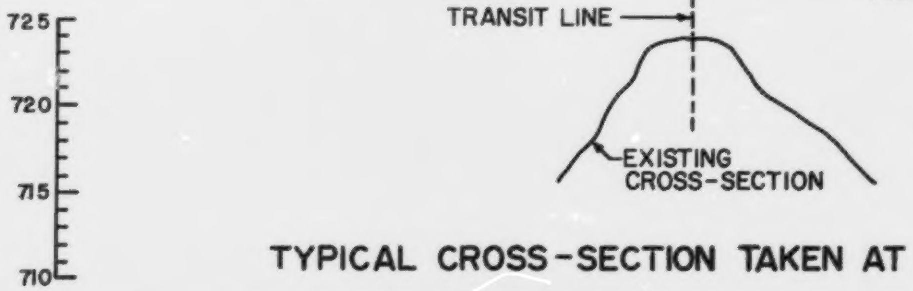
CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

LIBAU AREA DYKES
LAKE WINNIPEG TEMPORARY DYKING SYSTEM

SCALE AS SHOWN	DATE MAR. /74	SHEET 10 OF 22	FILE NO. 39-2-1233

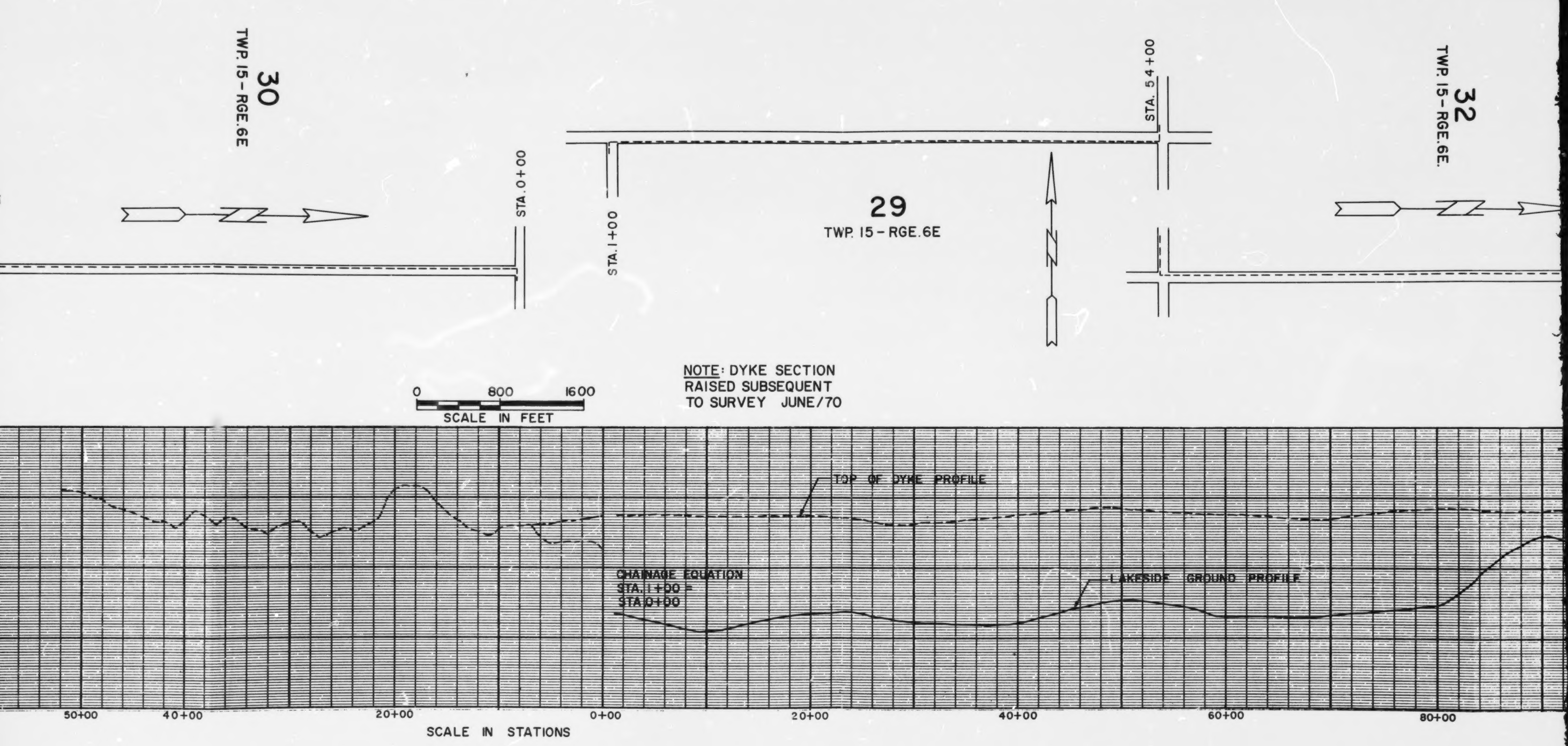
FIGURE 10


19
TWP. 15 - RGE. 6E.
30
TWP. 15 - RGE. 6E
STA. 468+50
STA. 414+00
STA. 52+00
ELEVATION IN FEET
730
725
720
715
710
CHAINAGE EQUATION
STA. 52+00 =
STA. 414+00
460+00
440+00
420+00
50+00
40+00


725
720
715
710
TRANSIT LINE
EXISTING CROSS-SECTION

TYPICAL CROSS-SECTION TAKEN AT STA. 20+00

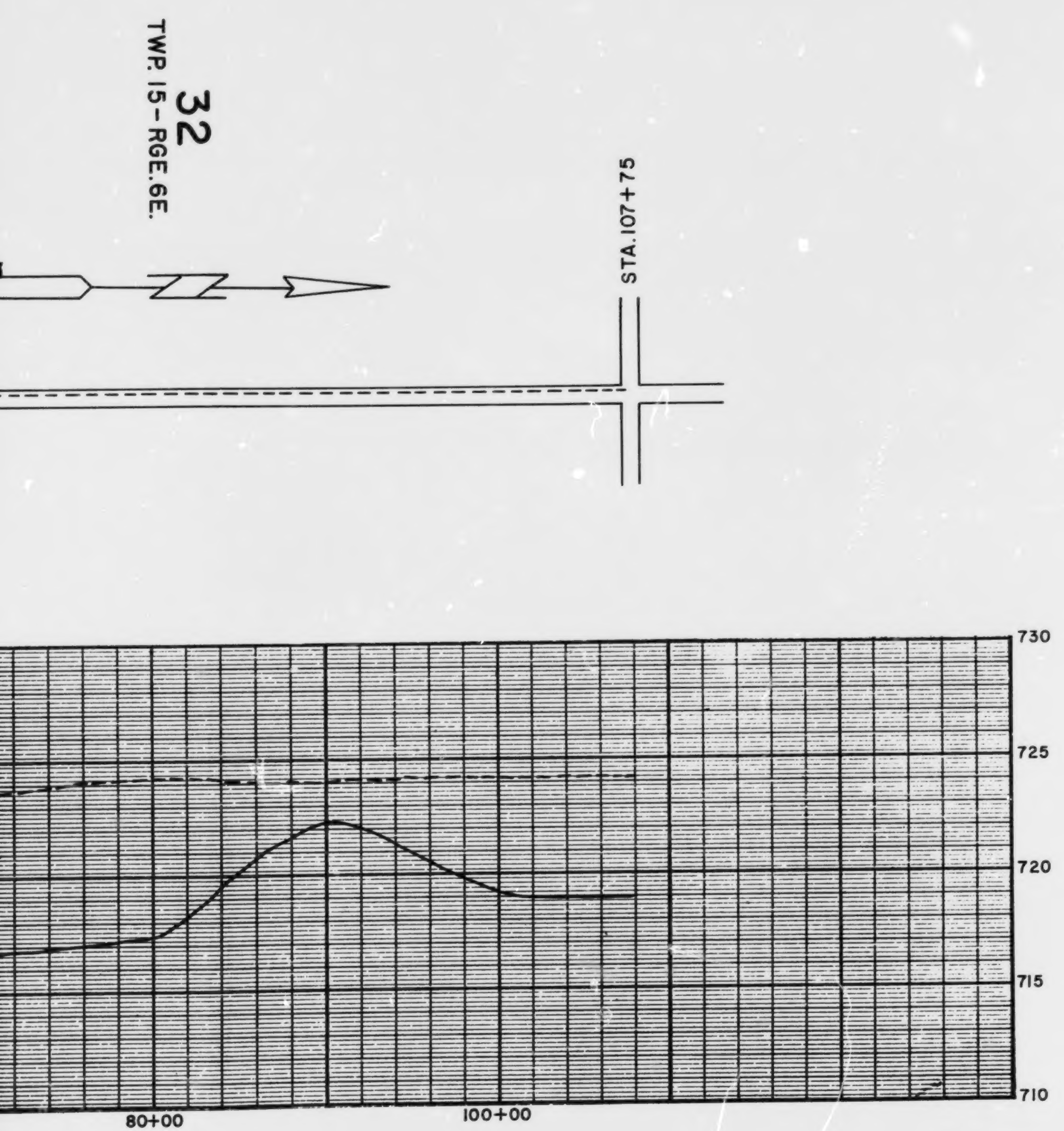
0
30
60
HORIZ. SCALE IN FEET


30
TWP. 15 - RGE. 6E
STA. 0+00
STA. 1+00
29
TWP. 15 - RGE. 6E
STA. 54+00
32
TWP. 15 - RGE. 6E.
0
800
1600
SCALE IN FEET
TOP OF DYKE PROFILE
CHAINAGE EQUATION
STA. 1+00 =
STA 0+00
LAKESIDE GROUND PROFILE
50+00
40+00
20+00
0+00
20+00
40+00
60+00
80+00
SCALE IN STATIONS

NOTE: DYKE SECTION
RAISED SUBSEQUENT
TO SURVEY JUNE/70

FIELD BOOKS 15-1-26L,
39-2-119L

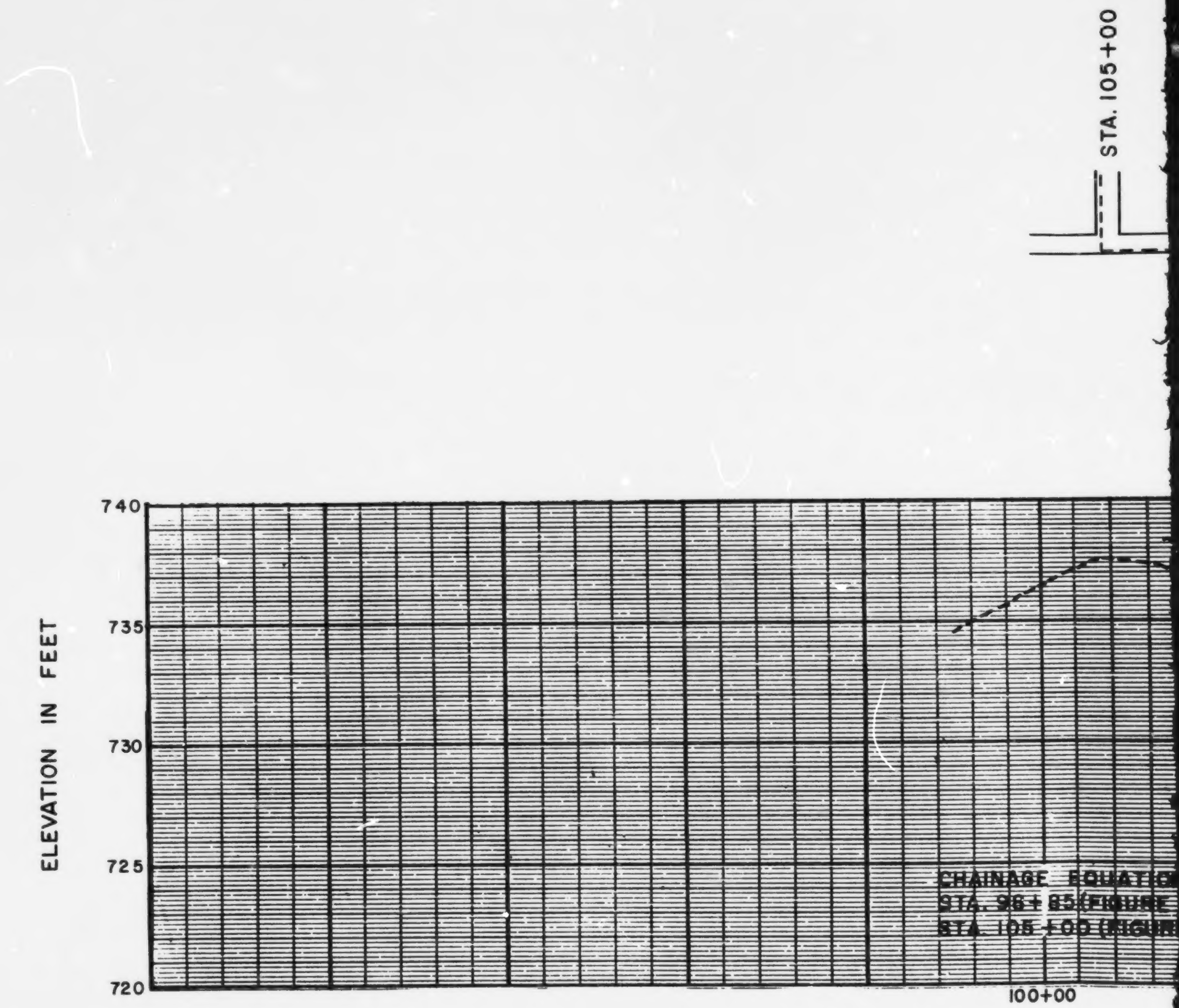
PRO
DEPARTMENT OF MINES,
WATER
PREPARED
DRAWN T.M.
CHECKED

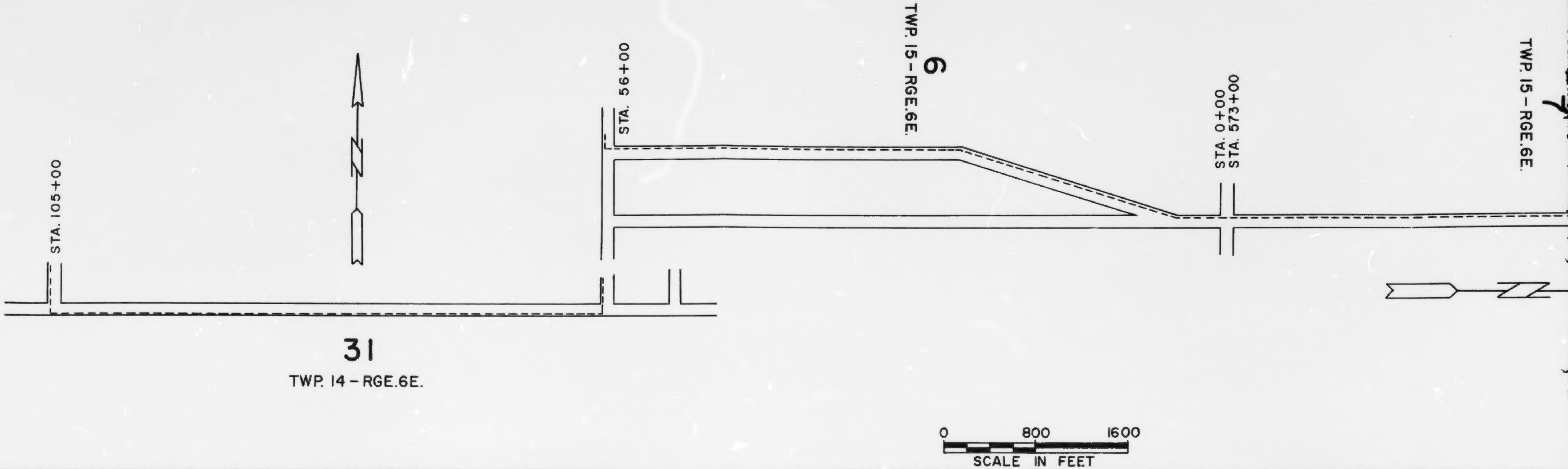

32
TWP. 15-RGE. 6E.
STA. 107+75
730
725
720
715
710
ELEVATION IN FEET
80+00
100+00

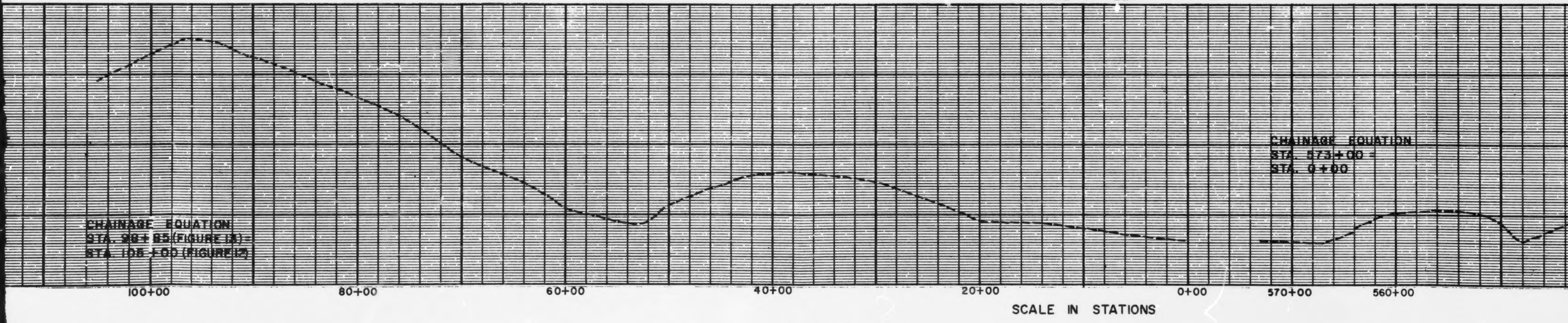
...OOKS 15-1-26L,
39-2-119L

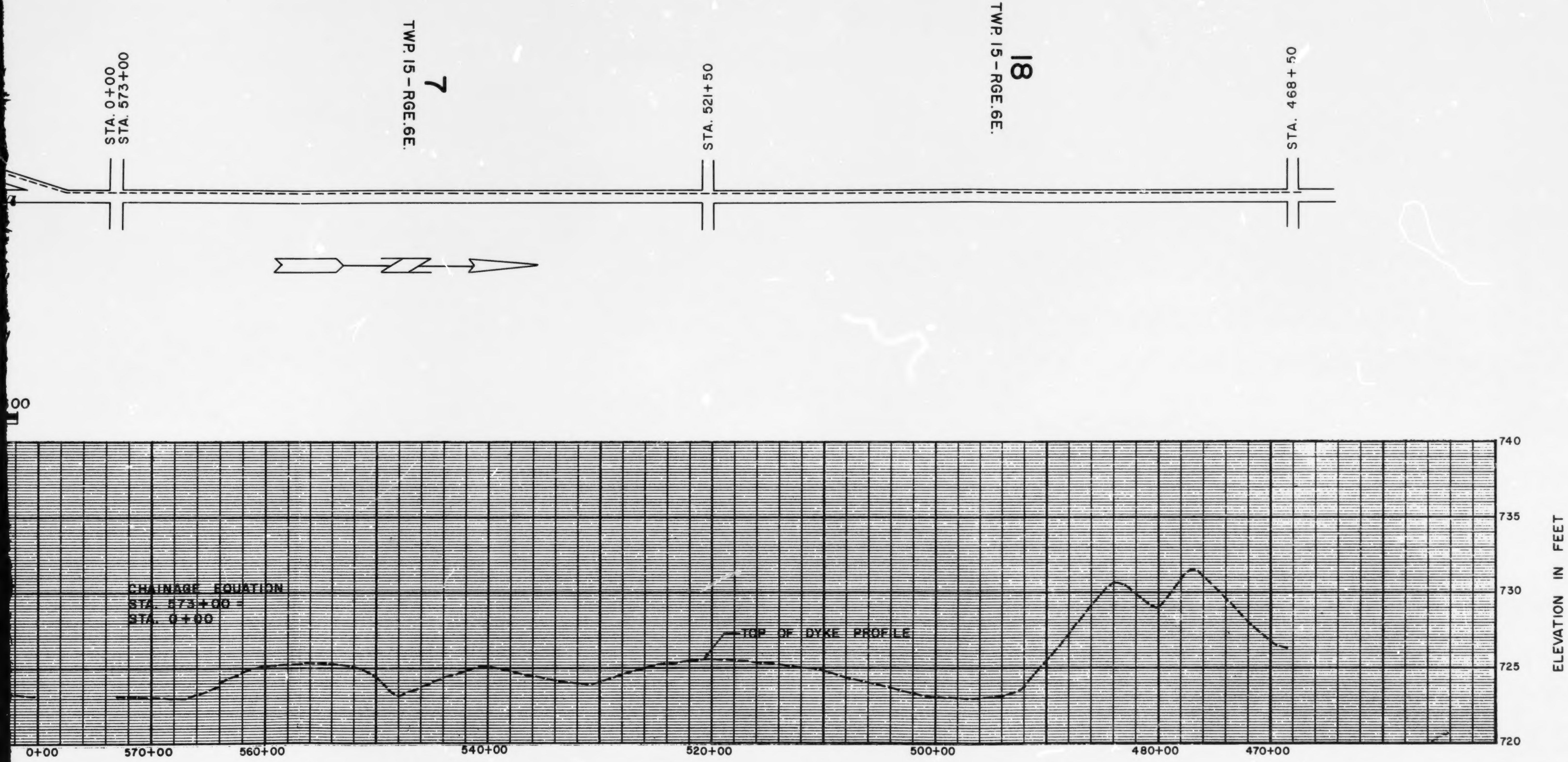
PROVINCE OF MANITOBA DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT WATER RESOURCES BRANCH				CANADA-MANITOBA LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD LIBAU AREA DYKES LAKE WINNIPEG TEMPORARY DYKING SYSTEM	
PREPARED	DRAWN T. M. CHECKED	SUBMITTED DATE	APPROVED DATE	SCALE AS SHOWN	DATE MAR./74
				SHEET 11 OF 22	FILE NO. 39-2-1233

FIGURE 11


STA. 105+00
740
735
730
725
720
ELEVATION IN FEET
100+00
CHAINAGE EQUATIO
STA. 96+85 (FIGURE
STA. 105+00 (FIGUR


STA. 105+00
STA. 56+00
TWP. 15 - RGE. 6E.
6
STA. 0+00
STA. 573+00
TWP. 15 - RGE. 6E.
31
TWP. 14 - RGE. 6E.
0
800
1600
SCALE IN FEET


CHAINAGE EQUATION
STA. 98+85 (FIGURE 13) =
STA. 105+00 (FIGURE 12)
CHAINAGE EQUATION
STA. 573+00 =
STA. 0+00
100+00
80+00
60+00
40+00
20+00
0+00
570+00
560+00
SCALE IN STATIONS


STA. 0+00
STA. 573+00
7
TWP. 15 - RGE. 6E.
STA. 521+50
18
TWP. 15 - RGE. 6E.
STA. 468+50
00
CHAINAGE EQUATION
STA. 573+00 =
STA. 0+00
TOP OF DYKE PROFILE
740
735
730
725
720
ELEVATION IN FEET
0+00
570+00
560+00
540+00
520+00
500+00
480+00
470+00

FIELD BOOK

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

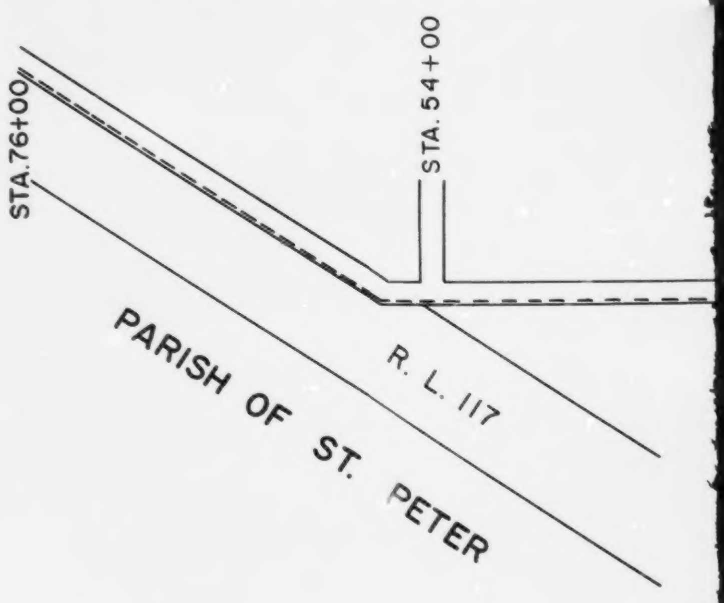
PREPARED	DRAWN T. M.	SUBMITTED	APPROVED
	CHECKED	DATE	DATE

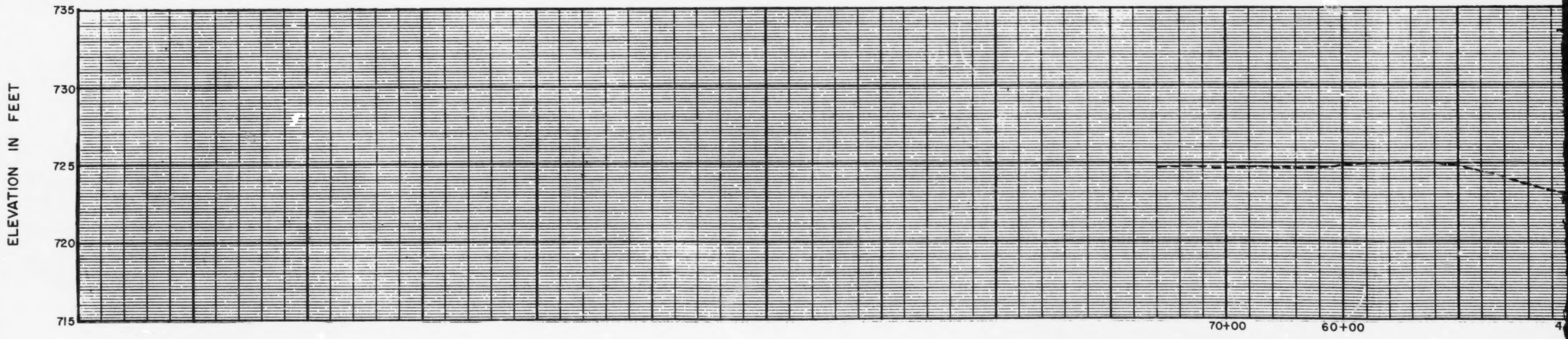
CANADA - MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

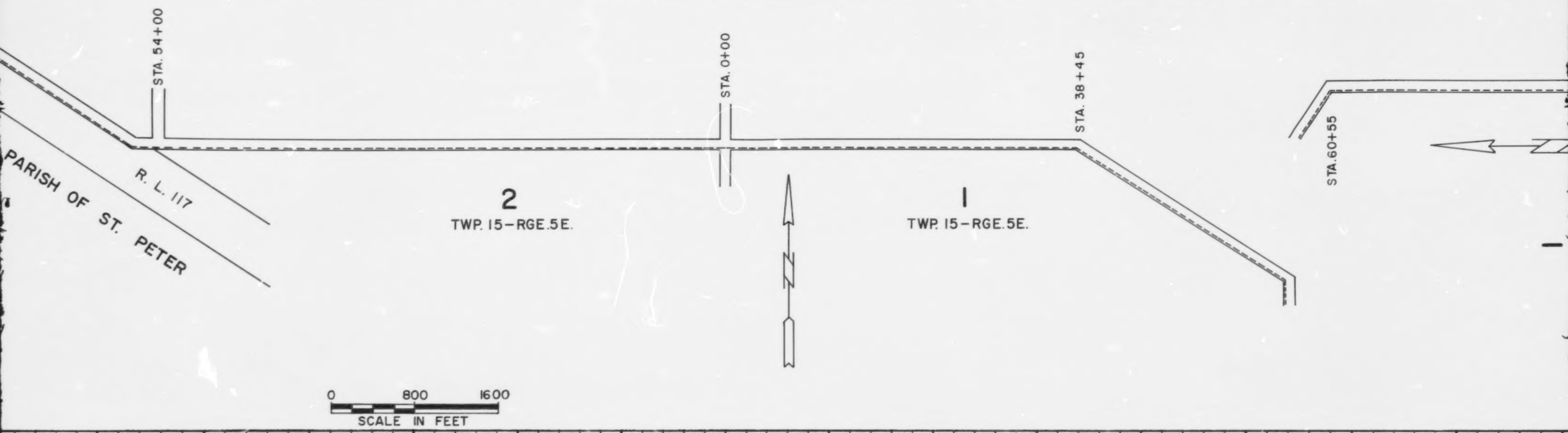
LIBAU AREA DYKES
LAKE WINNIPEG TEMPORARY DYKING SYSTEM

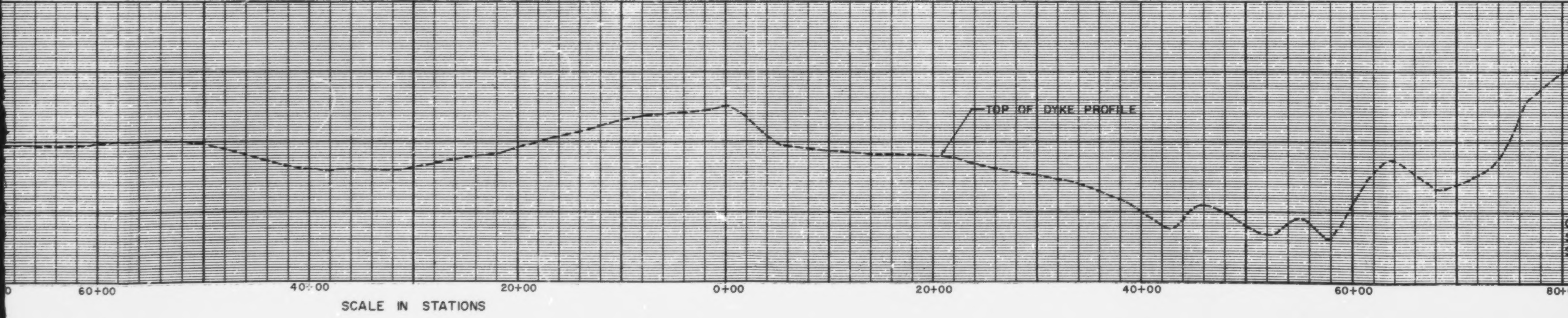
SCALE	DATE	SHEET	FILE NO.
AS SHOWN	MAR./74	12 OF 22	39-2-1233

FIGURE 12


STA. 76+00
STA. 54+00
R. L. 117
PARISH OF ST. PETER


ELEVATION IN FEET
735
730
725
720
715
70+00
60+00

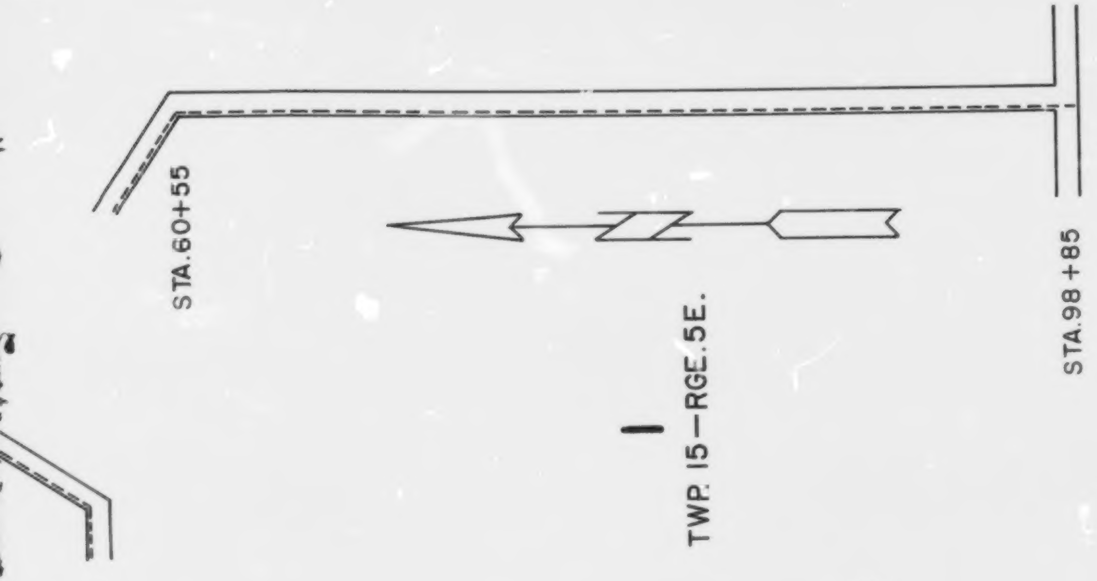

STA. 54+00
STA. 0+00
STA. 38+45
STA.60+55
PARISH OF ST. PETER
R. L. 117
2
TWP. 15-RGE.5E.
1
TWP. 15-RGE.5E.
0
800
1600
SCALE IN FEET

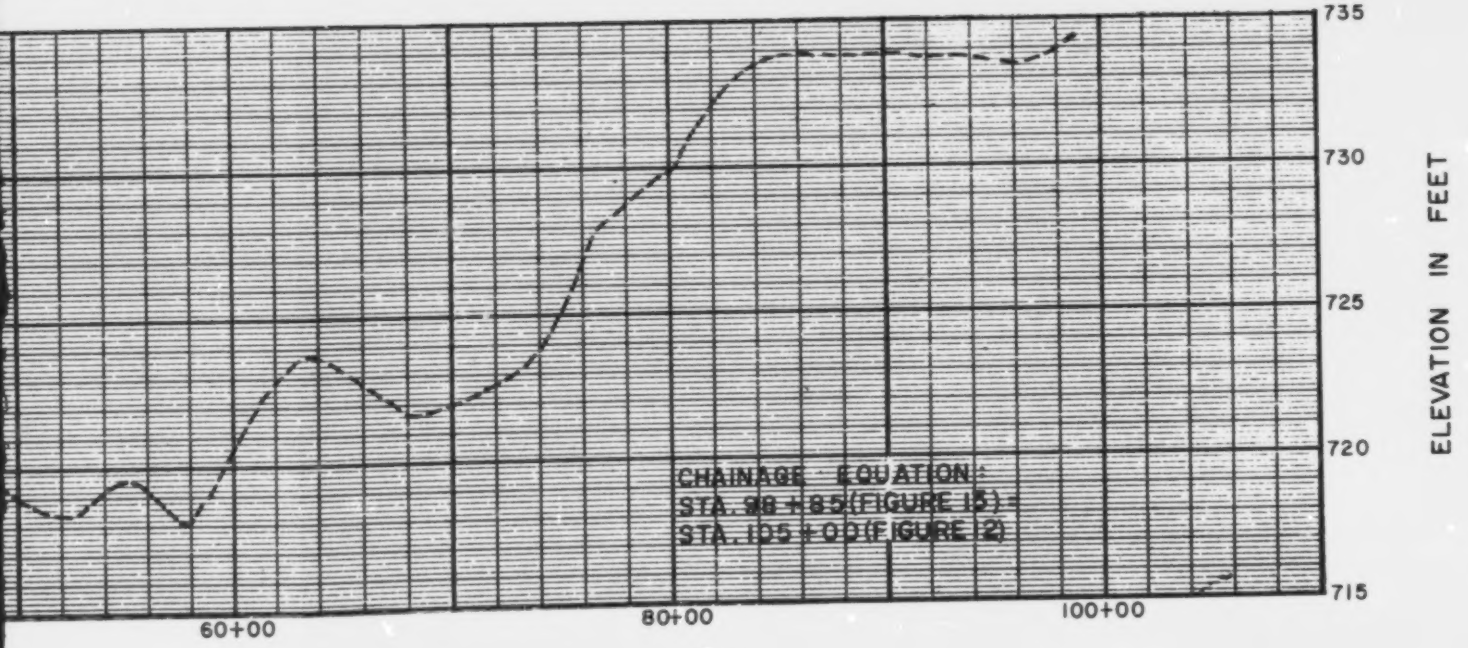


FIELD BOOK 39-2-122L

PROVINCE OF MANIT
DEPARTMENT OF MINES, RESOURCES AND ENVI
WATER RESOURCES

PREPARED	DRAWN T. M.	SUBMITTED
	CHECKED	DATE





PROVINCE OF MANITOBA

DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

WATER RESOURCES BRANCH

PREPARED	DRAWN T. M.	SUBMITTED	APPROVED
	CHECKED	DATE	DATE

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

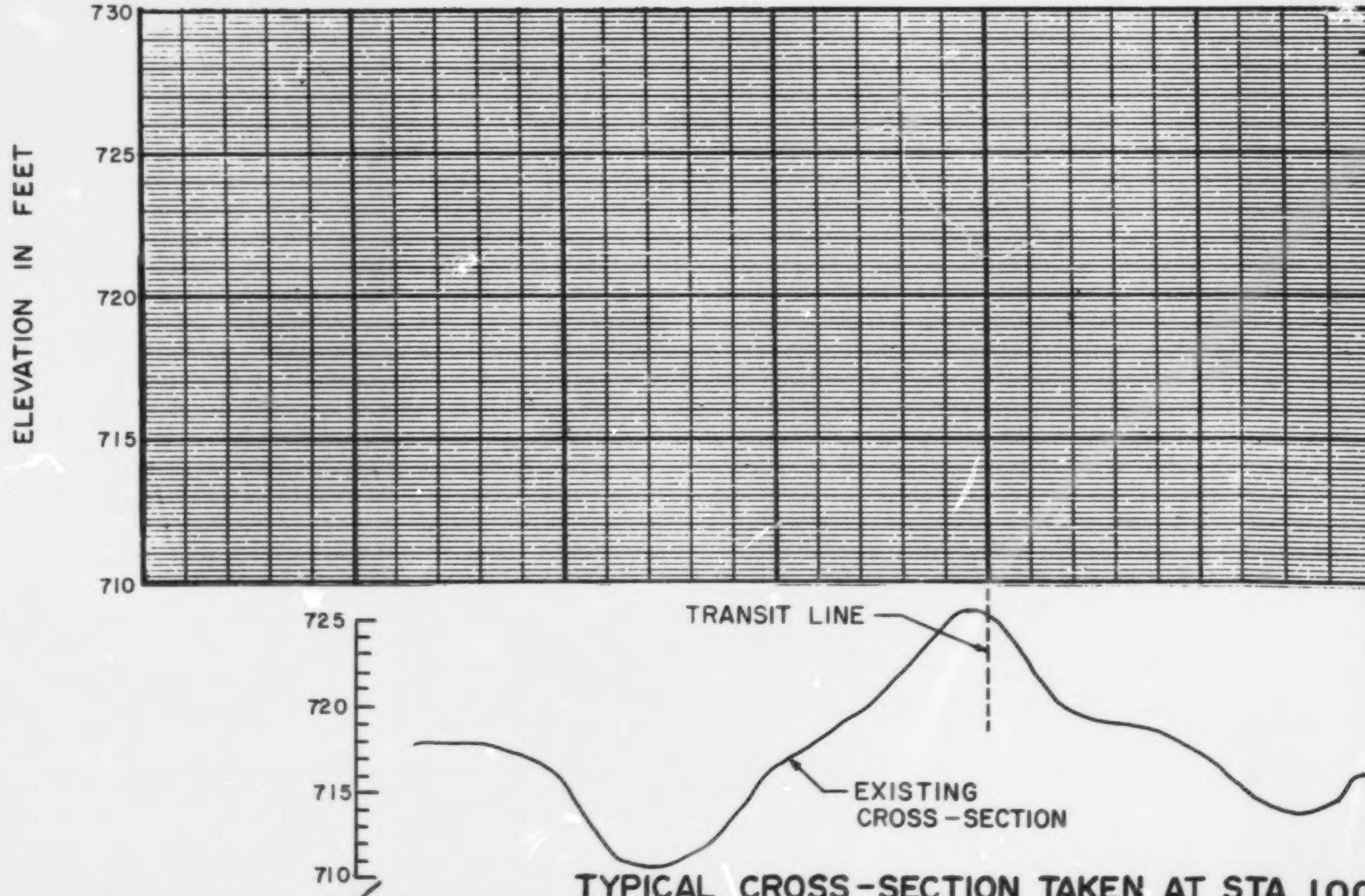
LIBAU AREA DYKES

LAKE WINNIPEG TEMPORARY DYKING SYSTEM

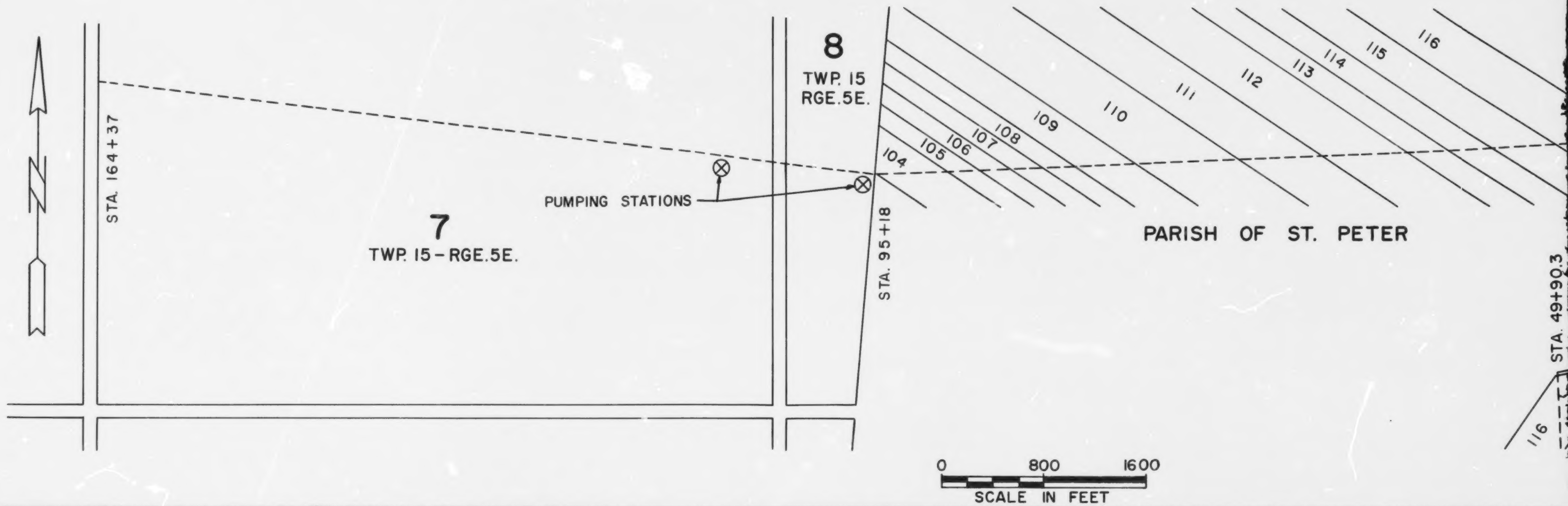
SCALE	DATE	SHEET	FILE NO.
AS SHOWN	MAR./74	13 OF 22	39-2-1233

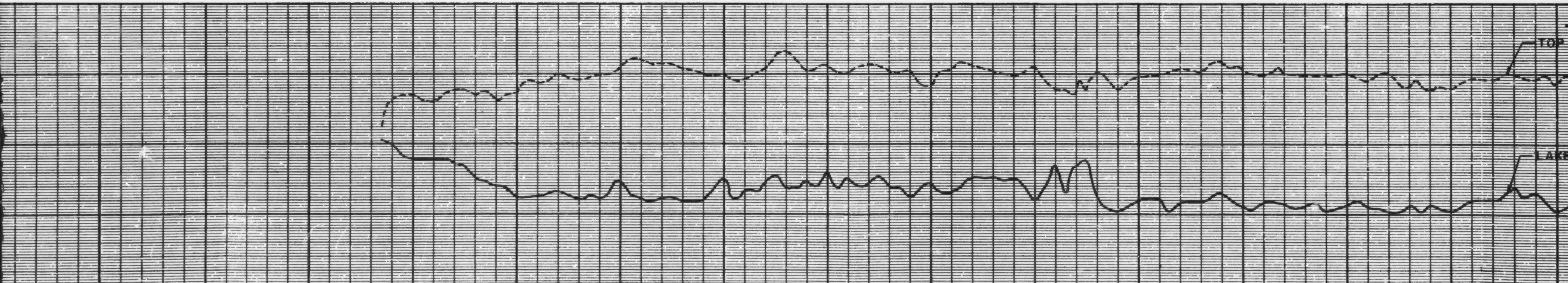
BOOK 39-2-122L

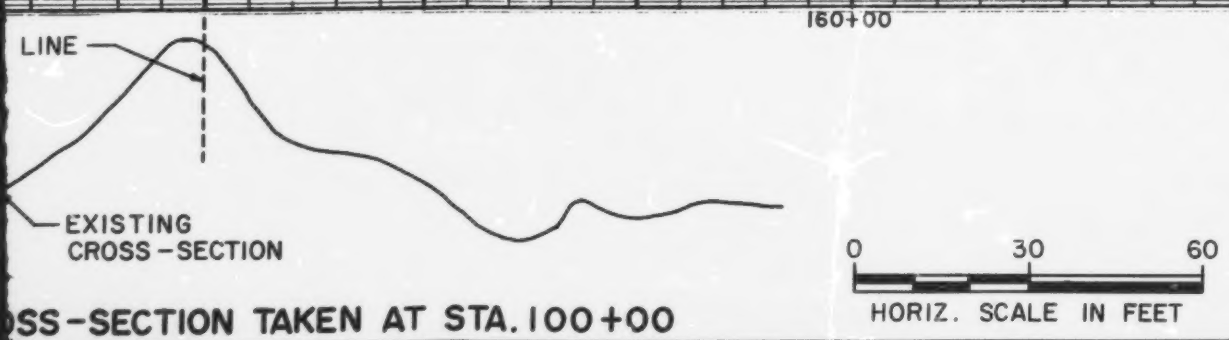
FIGURE 13


ELEVATION IN FEET
730
725
720
715
710
TRANSIT LINE
725
720
715
710
EXISTING CROSS-SECTION

TYPICAL CROSS-SECTION TAKEN AT STA. 10

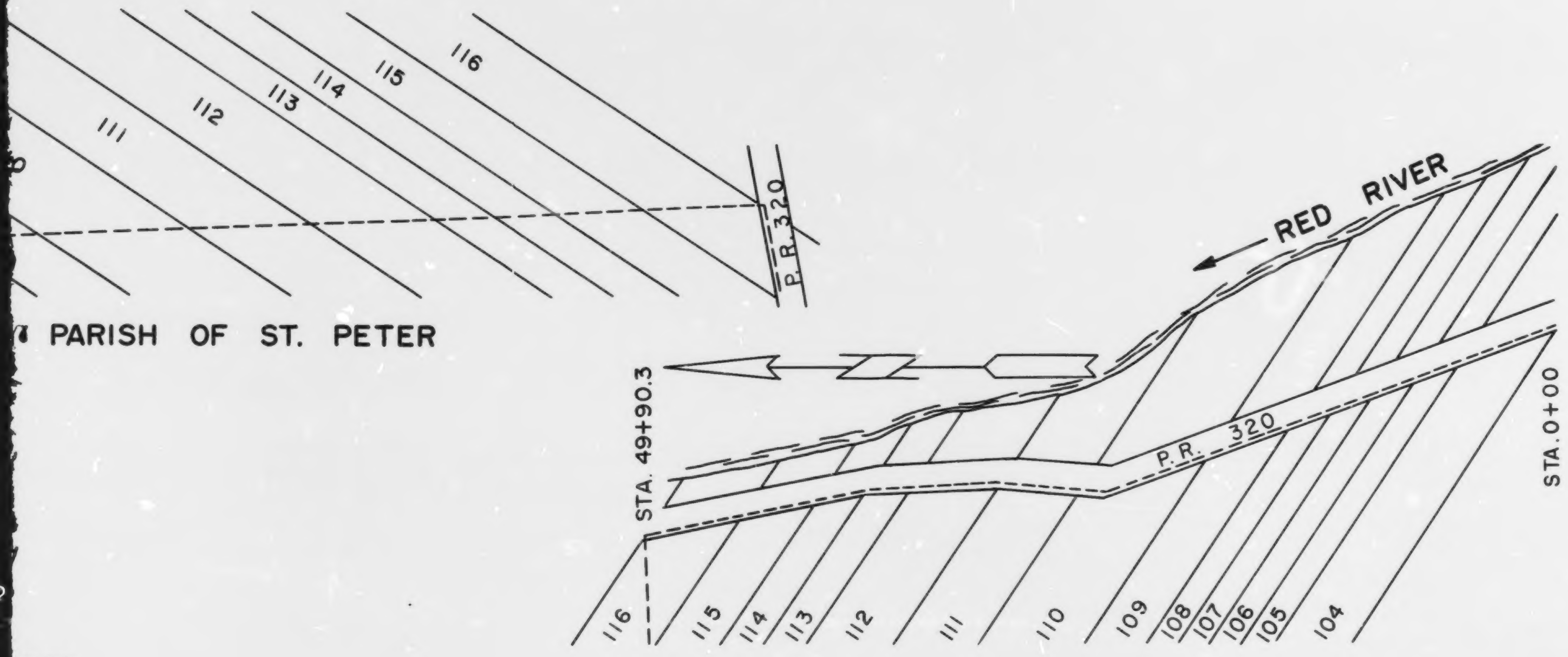

N
STA. 164+37
7
TWP. 15 - RGE. 5E.
PUMPING STATIONS
8
TWP. 15
RGE. 5E.
STA. 95+18
104
105
106
107
108
109
110
111
112
113
114
115
116
PARISH OF ST. PETER
STA. 49+90.3
116
0
800
1600
SCALE IN FEET



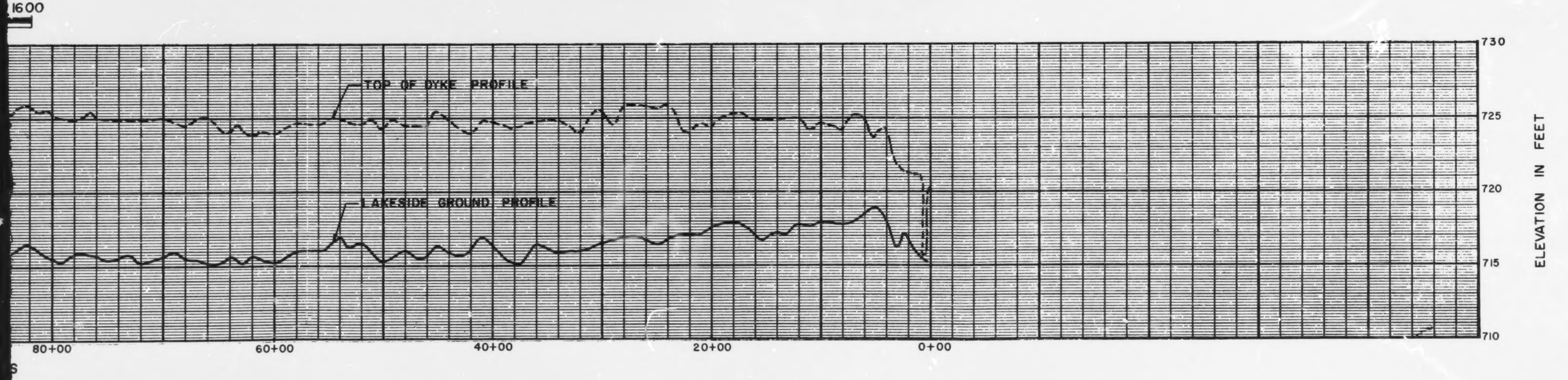

LINE
EXISTING
CROSS-SECTION
0
30
60
HORIZ. SCALE IN FEET

OSS-SECTION TAKEN AT STA. 100+00

FIGURE 11



111
112
113
114
115
116
P.R. 320
RED RIVER
PARISH OF ST. PETER
STA. 49+90.3
P.R. 320
STA. 0+00
116
115
114
113
112
111
110
109
108
107
106
105
104



FIELD BOOK 39-2-49F

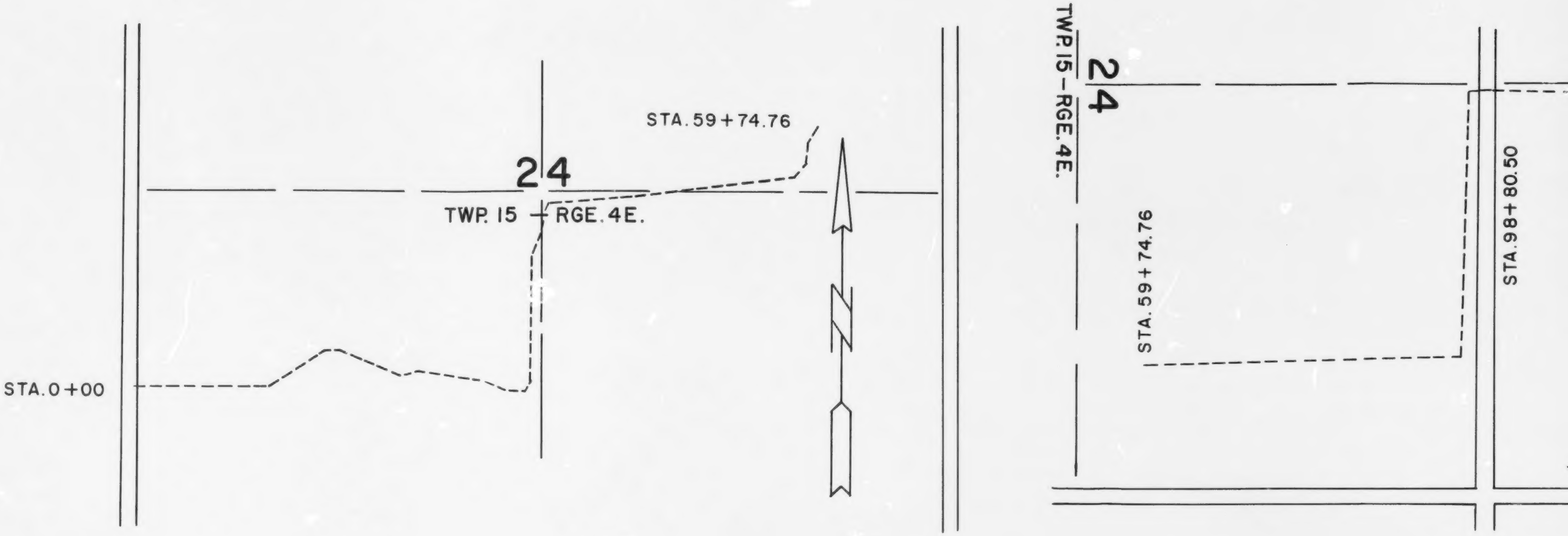
PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

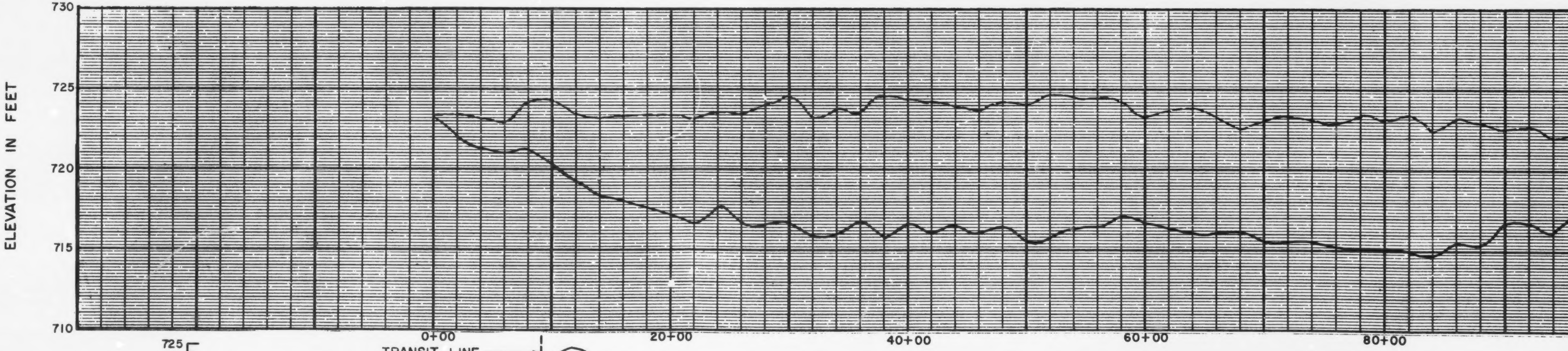
PREPARED
DRAWN T. M.
CHECKED
SUBMITTED
DATE
APPROVED
DATE

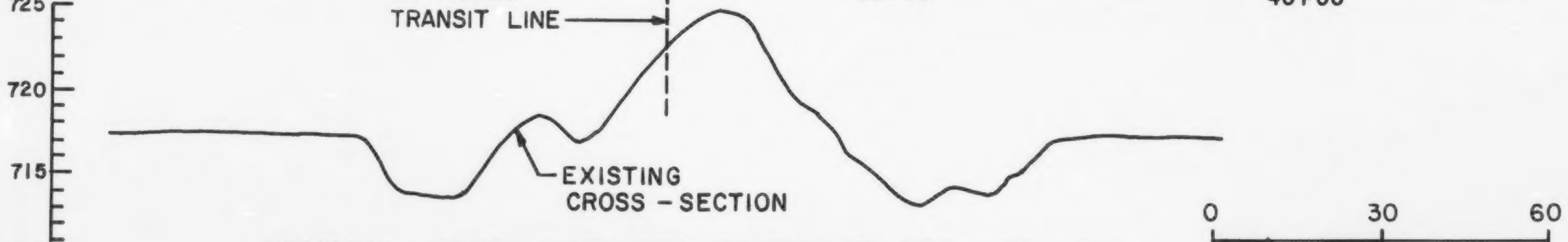
CANADA - MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

DUCKS UNLIMITED DYKE
LAKE WINNIPEG TEMPORARY DYKING SYSTEM

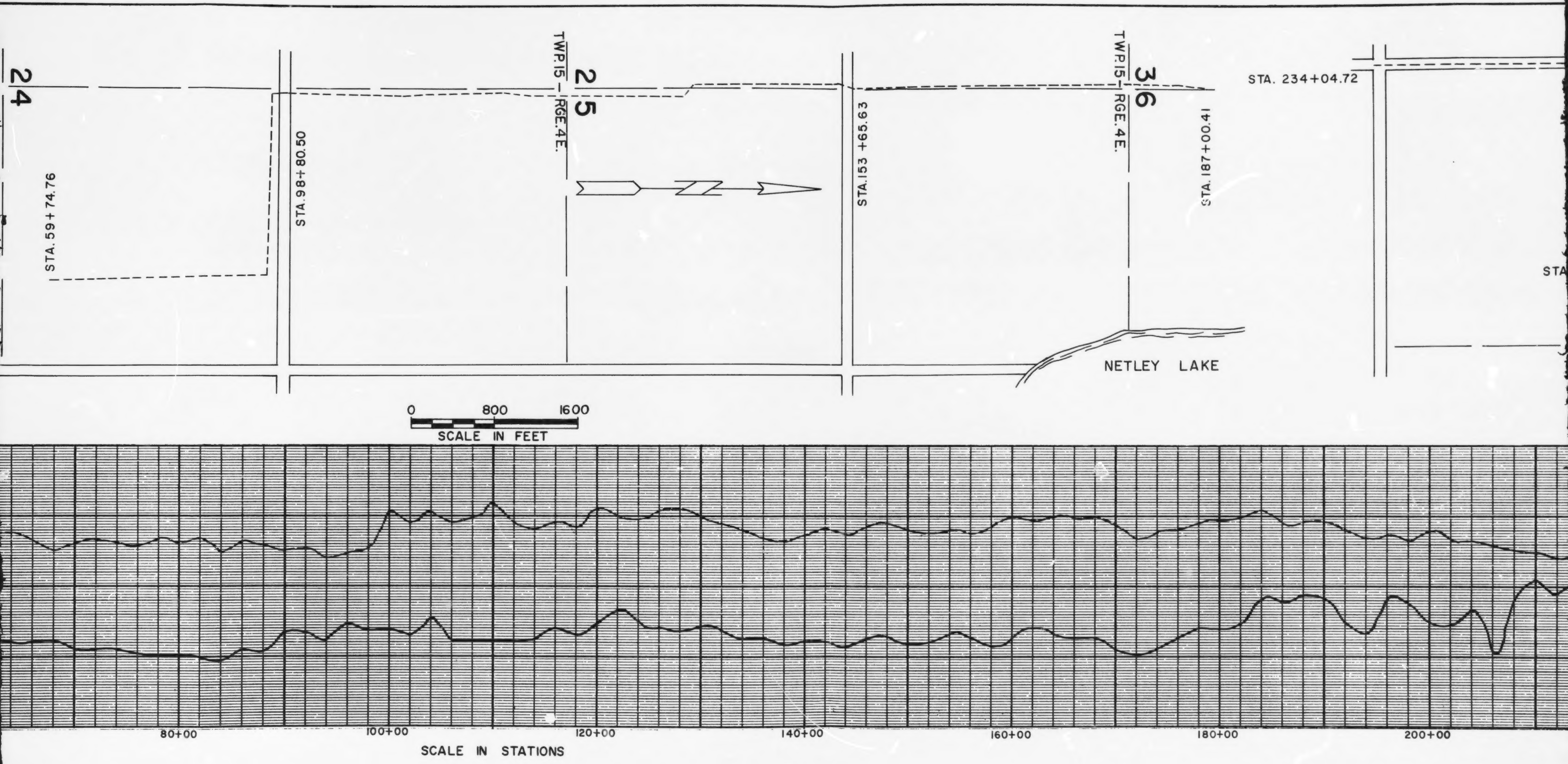
SCALE AS SHOWN
DATE MAR. /74
SHEET 14 OF 22
FILE NO. 39-2-1233


STA. 59+74.76
24
TWP. 15
RGE. 4E.
STA. 0+00
N
24
TWP. 15 - RGE. 4E.
STA. 59+74.76
STA. 98+80.50




725
720
715
710
TRANSIT LINE
EXISTING CROSS - SECTION
0
30
60
HORIZ. SCALE IN FEET

TYPICAL CROSS-SECTION TAKEN AT STA. 125+00


24
STA. 59+74.76
STA. 98+80.50
TWP. 15 – RGE. 4 E.
25
STA. 153+65.63
TWP. 15 – RGE. 4 E.
36
STA. 187+00.41
STA. 234+04.72
STA
NETLEY LAKE
0
800
1600
SCALE IN FEET
80+00
100+00
120+00
140+00
160+00
180+00
200+00
SCALE IN STATIONS

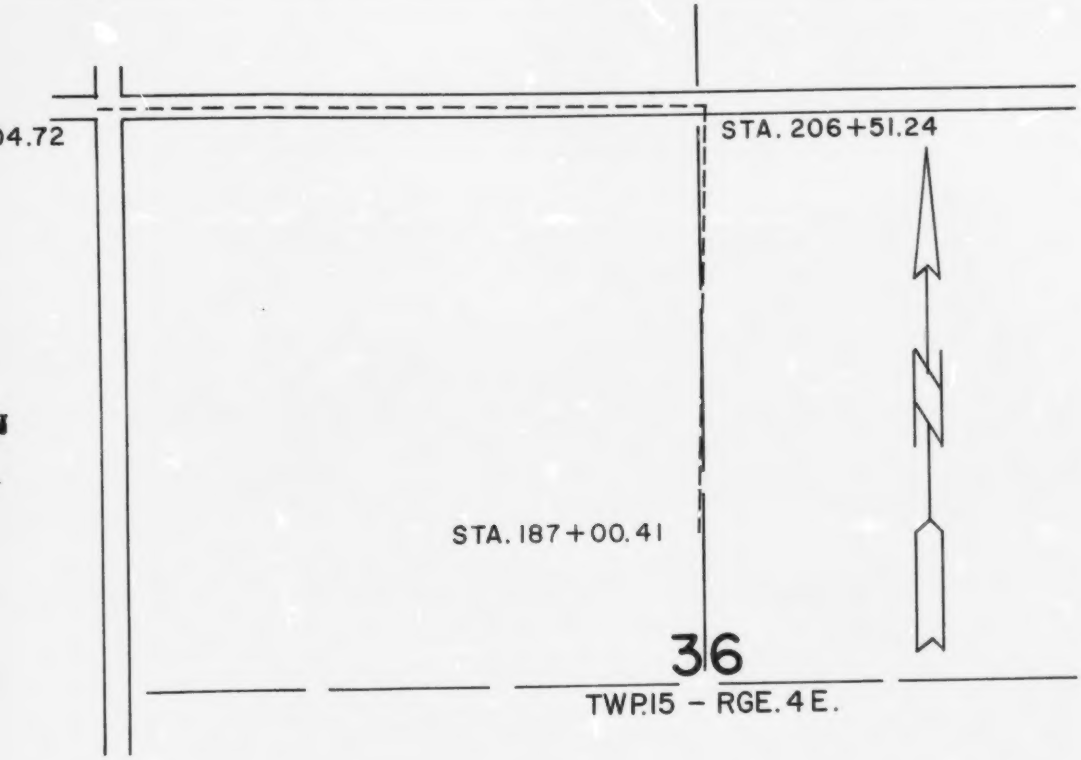
FIELD BOOKS 39-2-40F, -112L

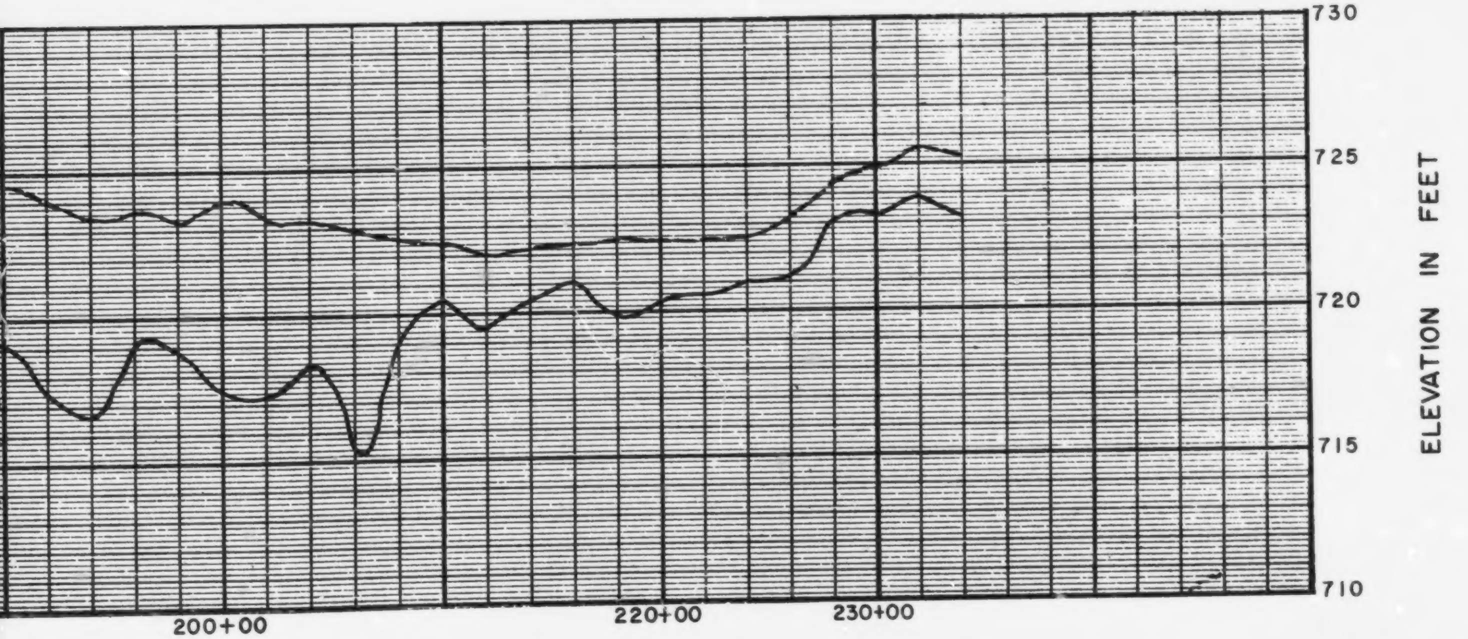
PROV

DEPARTMENT OF MINES, RE

WATER R

PREPARED	DRAWN T. M.
	CHECKED


4.72
STA. 206+51.24
N
STA. 187+00.41
36
TWP.15 - RGE. 4 E.



BOOKS 39-2-40F,
-112L

PROVINCE OF MANITOBA

DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

WATER RESOURCES BRANCH

PREPARED	DRAWN T. M.	SUBMITTED	APPROVED
	CHECKED	DATE	DATE

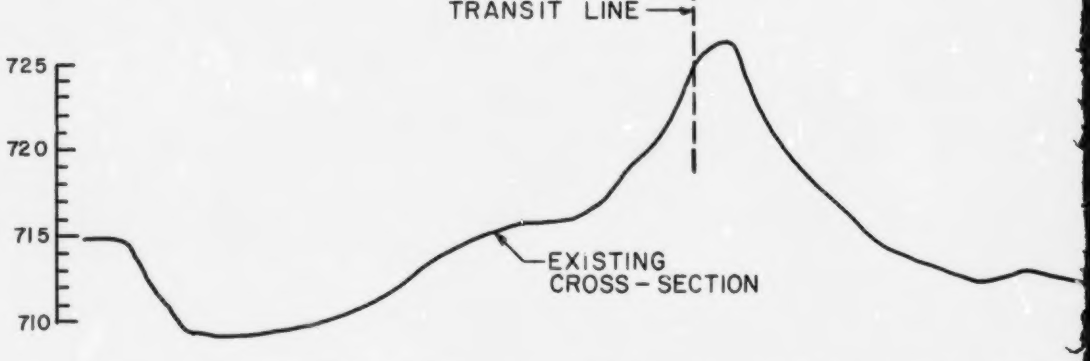
CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

PETERSFIELD DYKE

LAKE WINNIPEG TEMPORARY DYKING SYSTEM

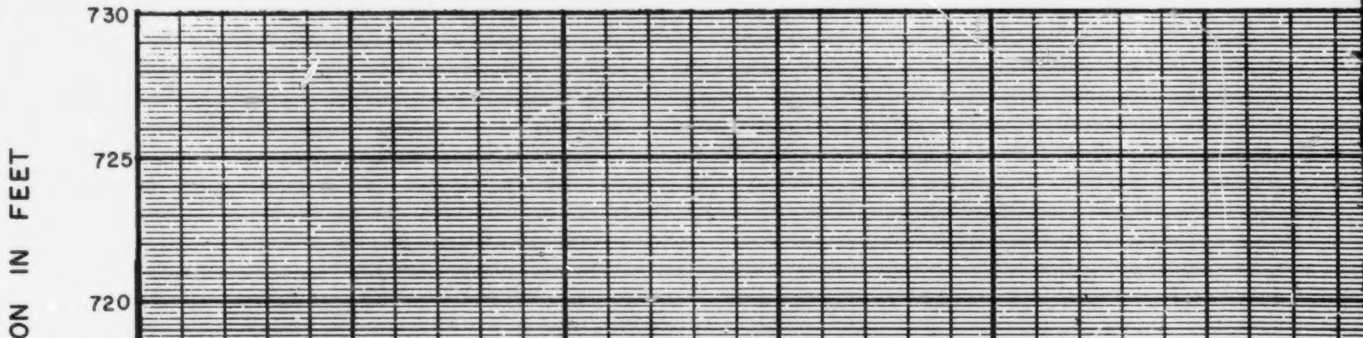
SCALE	DATE	SHEET	FILE NO.
AS SHOWN	MAR./74	15 OF 22	39-2-1233

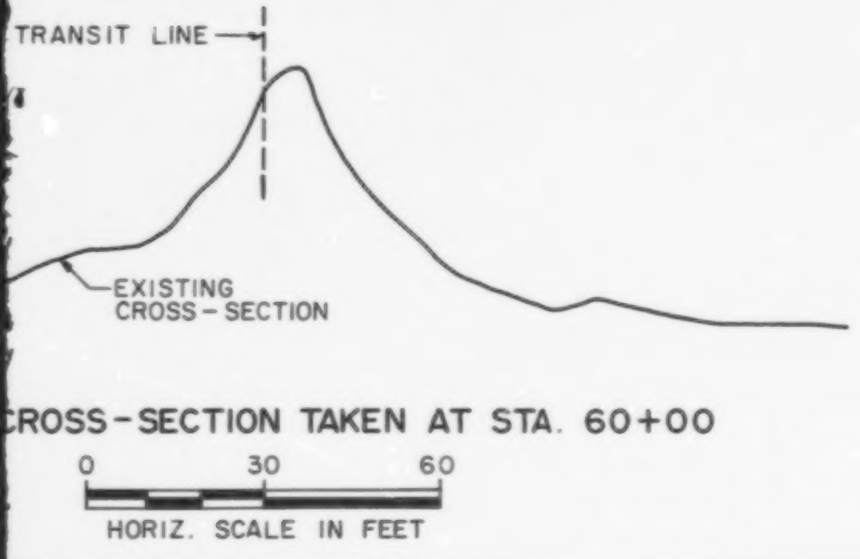
FIGURE 15


TRANSIT LINE
725
720
715
710
EXISTING CROSS - SECTION

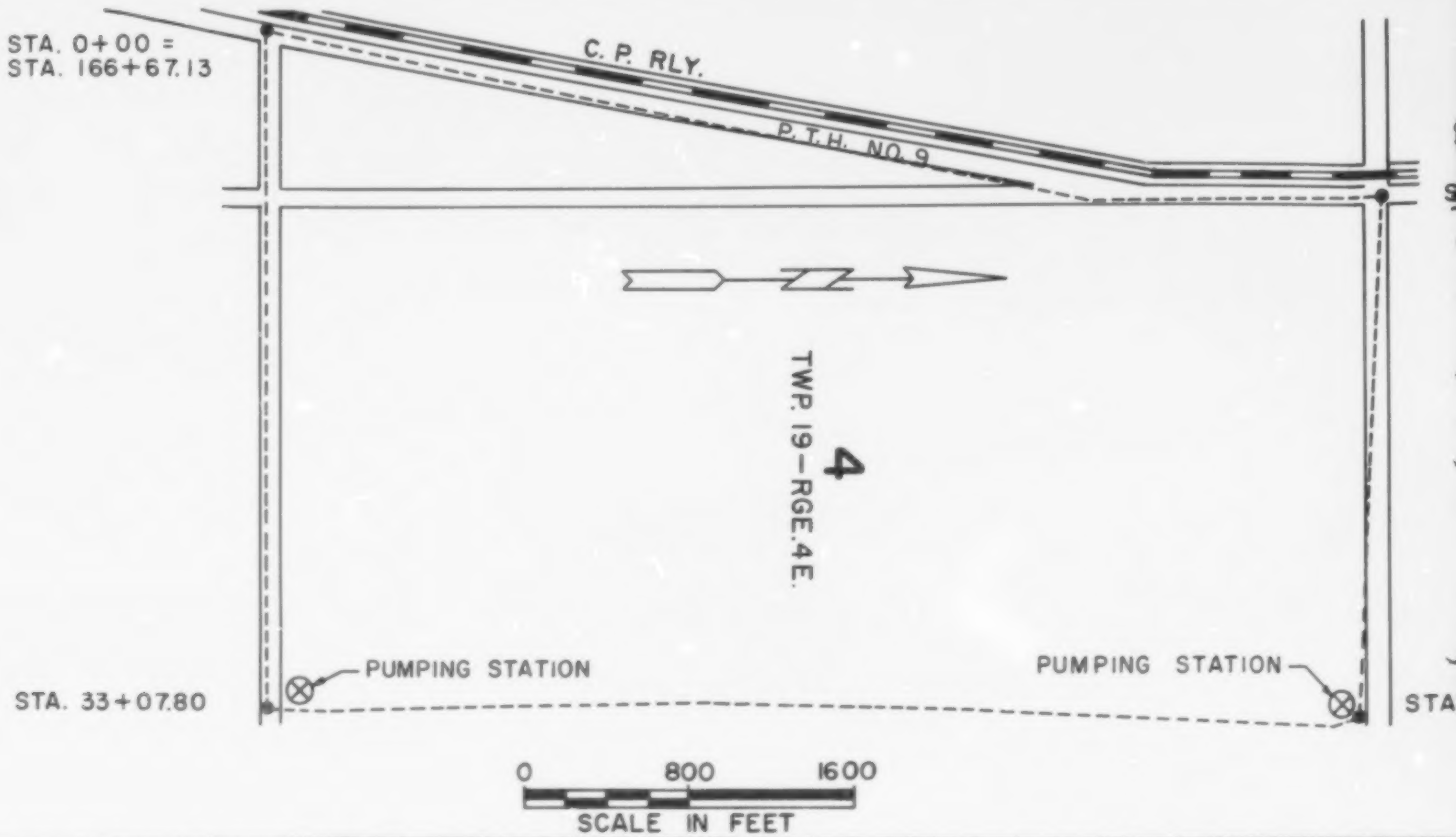
TYPICAL CROSS-SECTION TAKEN AT STA. 60

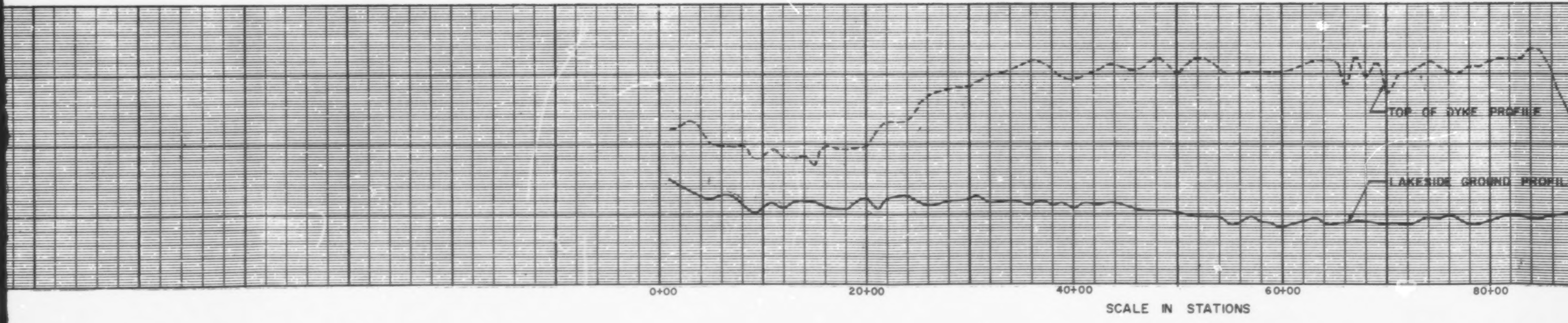
0
30
60
HORIZ. SCALE IN FEET

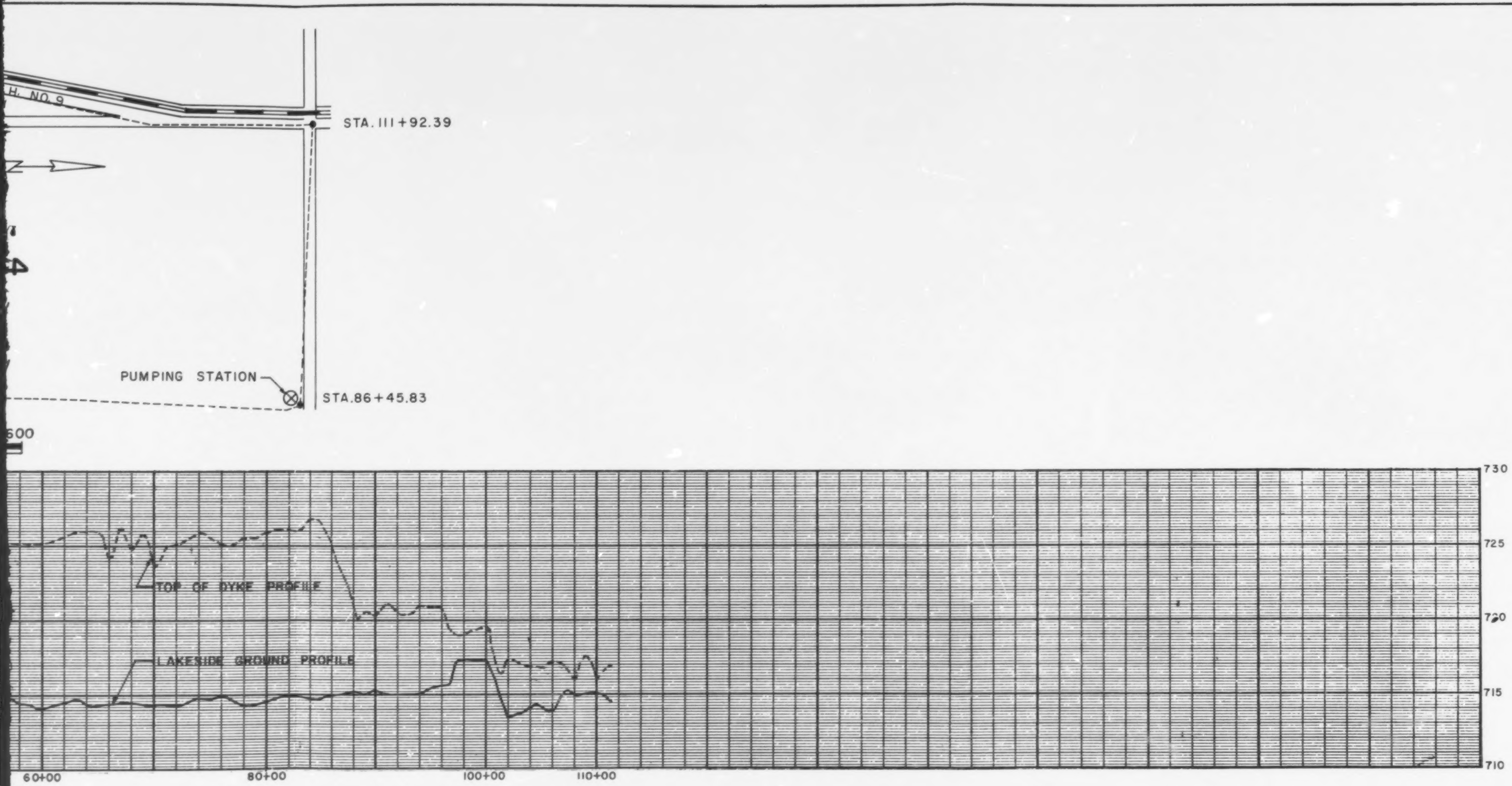



TRANSIT LINE
EXISTING CROSS-SECTION
0
30
60
HORIZ. SCALE IN FEET

CROSS-SECTION TAKEN AT STA. 60+00


STA. 0+00 =
STA. 166+67.13
C. P. RLY.
P.T.H. NO. 9
TWP. 19 – RGE. 4 E.
4
PUMPING STATION
PUMPING STATION
STA. 33+07.80
STA
0
800
1600
SCALE IN FEET

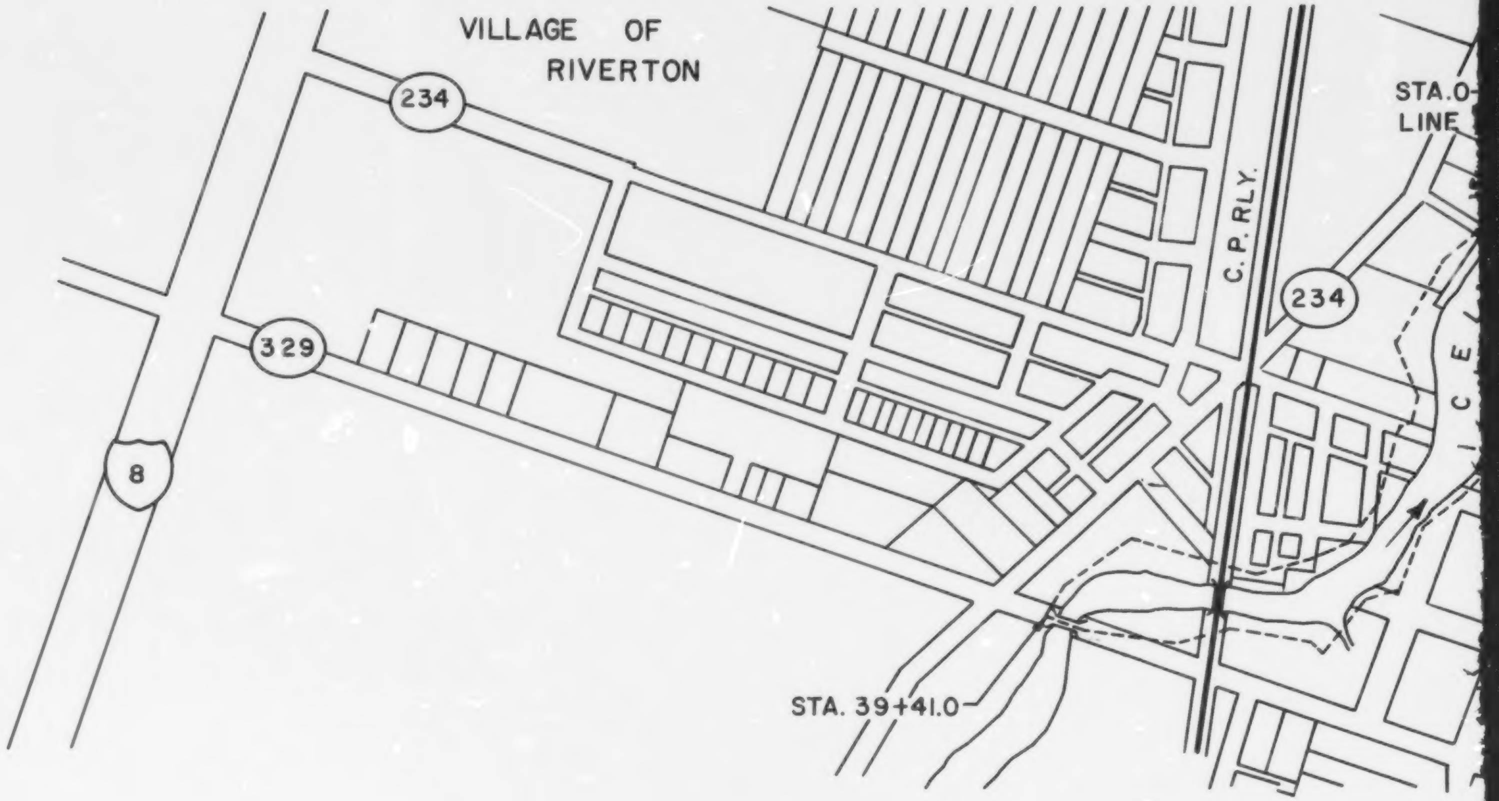


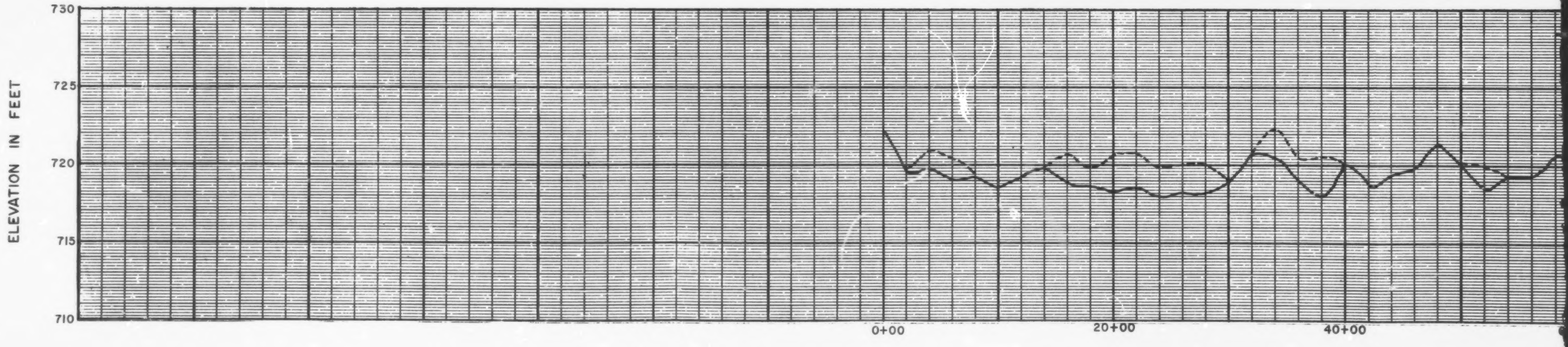

H. NO. 9
STA. 111+92.39
PUMPING STATION
STA.86+45.83
600
TOP OF DYKE PROFILE
LAKESIDE GROUND PROFILE
60+00
80+00
100+00
110+00
730
725
720
715
710
ELEVATION IN FEET

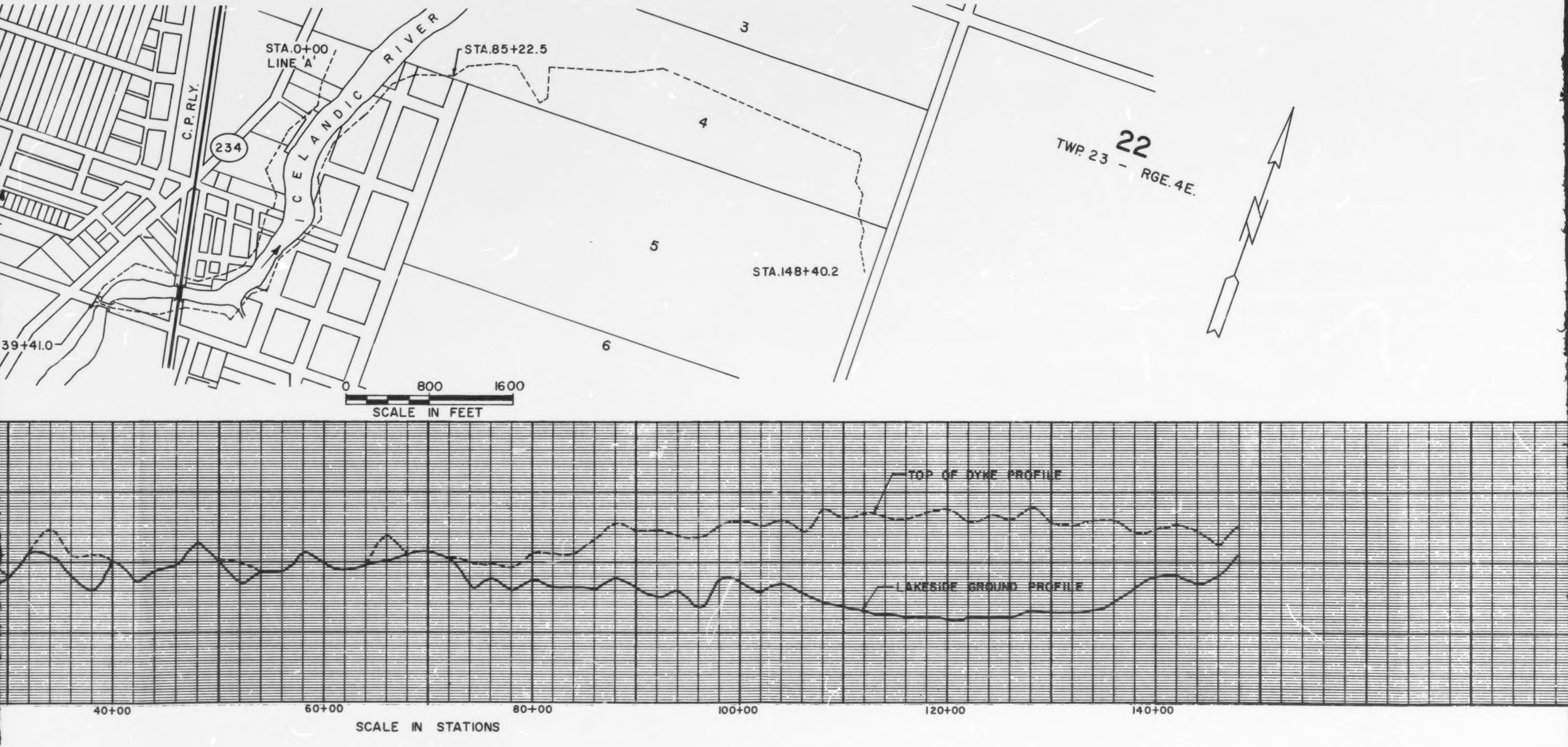
FIELD BOOKS 39-2-46F
-118L

PROVINCE OF MANITOBA DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT WATER RESOURCES BRANCH			CANADA - MANITOBA LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD ARNASON'S DYKE - SOUTH OF GIMLI LAKE WINNIPEG TEMPORARY DYKING SYSTEM
PREPARED	DRAWN T. M. CHECKED	SUBMITTED DATE	SCALE AS SHOWN
		DATE	DATE MAR./74
			SHEET 16 OF 22
			FILE NO. 39-2-1233

FIGURE 16

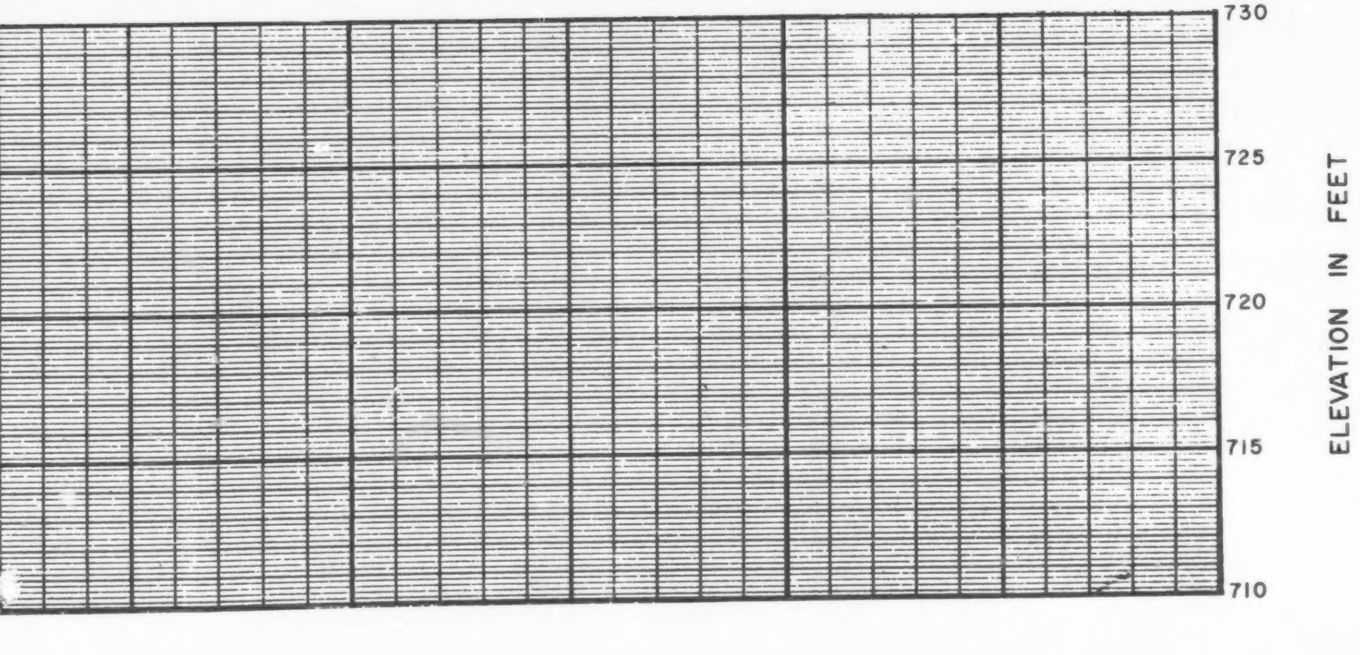

VILLAGE OF
RIVERTON
234
329
8
C.P. RLY.
234
STA.0-
LINE
STA. 39+41.0


730
725
720
715
710
ELEVATION IN FEET
0+00
20+00
40+00


STA.0+00
LINE 'A'
STA.85+22.5
ICELANDIC RIVER
C.P. RLY.
234
3
4
5
6
22
TWP. 23 - RGE. 4E.
STA.148+40.2
39+41.0
0
800
1600
SCALE IN FEET
TOP OF DYKE PROFILE
LAKESIDE GROUND PROFILE
40+00
60+00
80+00
100+00
120+00
140+00
SCALE IN STATIONS

FIELD BOOKS 39-2-42F
-115L

PROVINCE OF MA		
DEPARTMENT OF MINES, RESOURCES AND E		
WATER RESOURCE		
PREPARED	DRAWN T. M.	SUBMITTED
	CHECKED	DATE



PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

RIVERTON AND NORTH AREA DYKES
LAKE WINNIPEG TEMPORARY DYKING SYSTEM

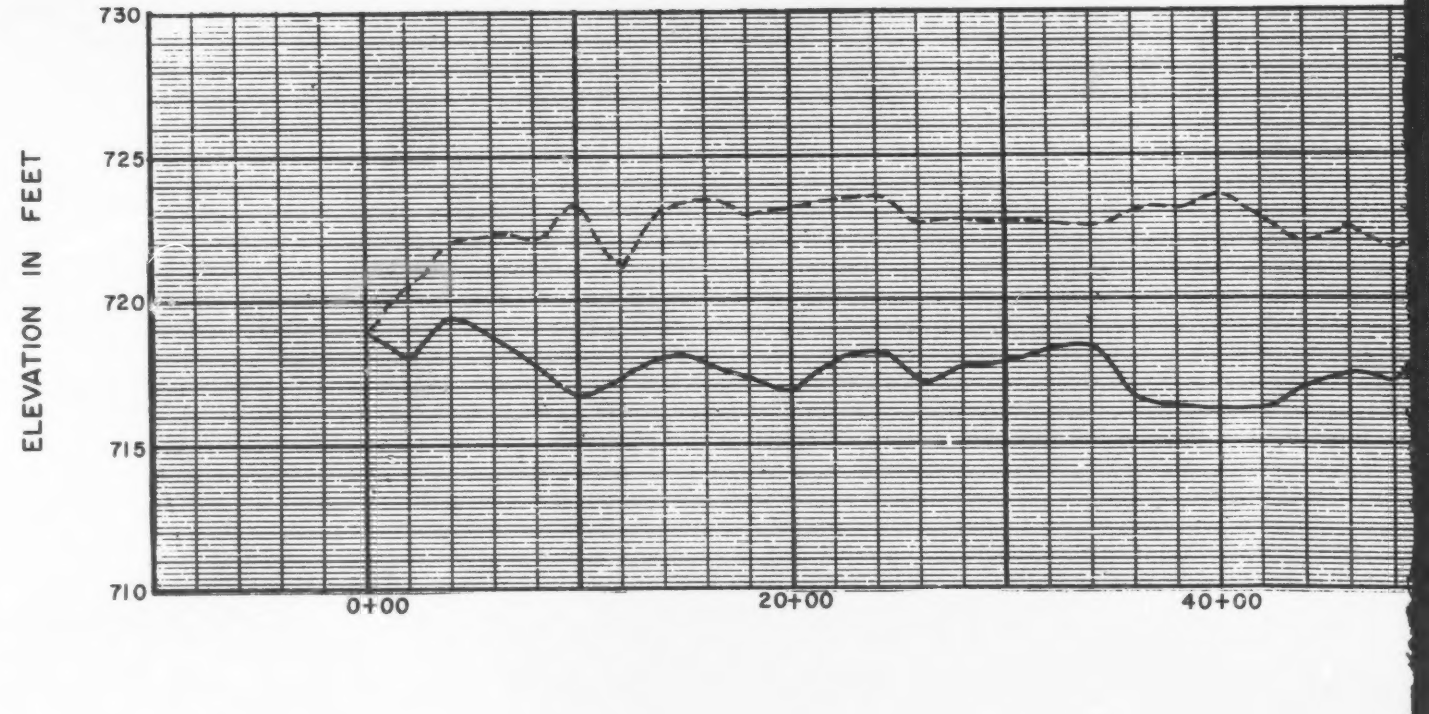
PREPARED	DRAWN T. M.	SUBMITTED	APPROVED
	CHECKED	DATE	DATE

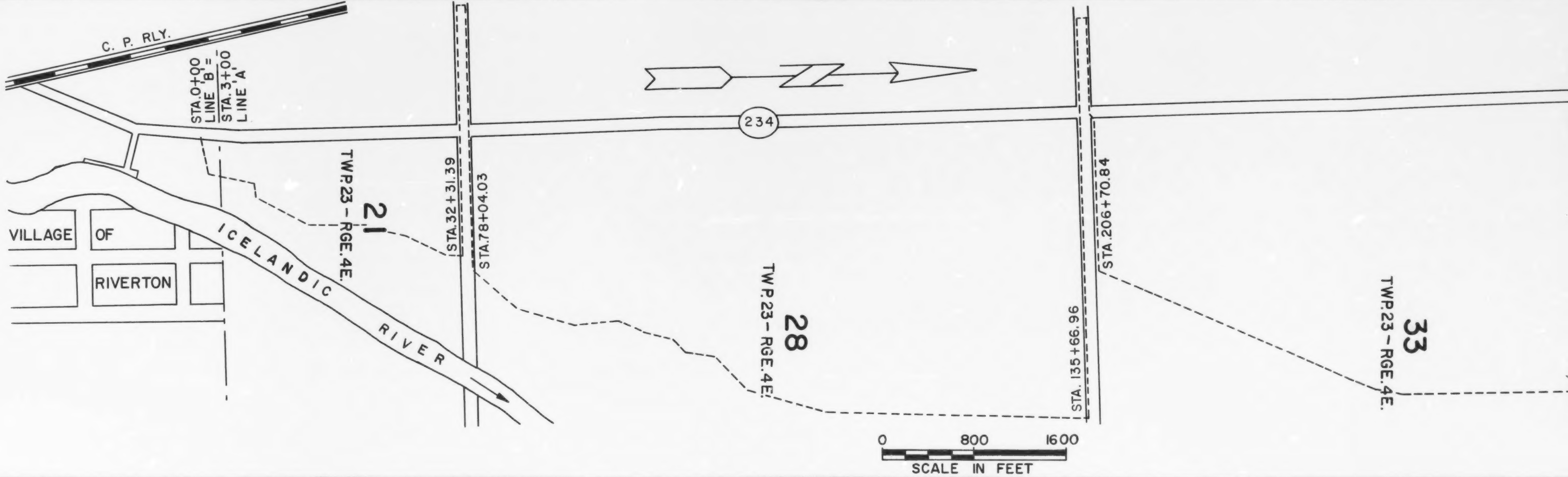
SCALE AS SHOWN	DATE MAR./74	SHEET 17 OF 22	FILE NO. 39-2-1233

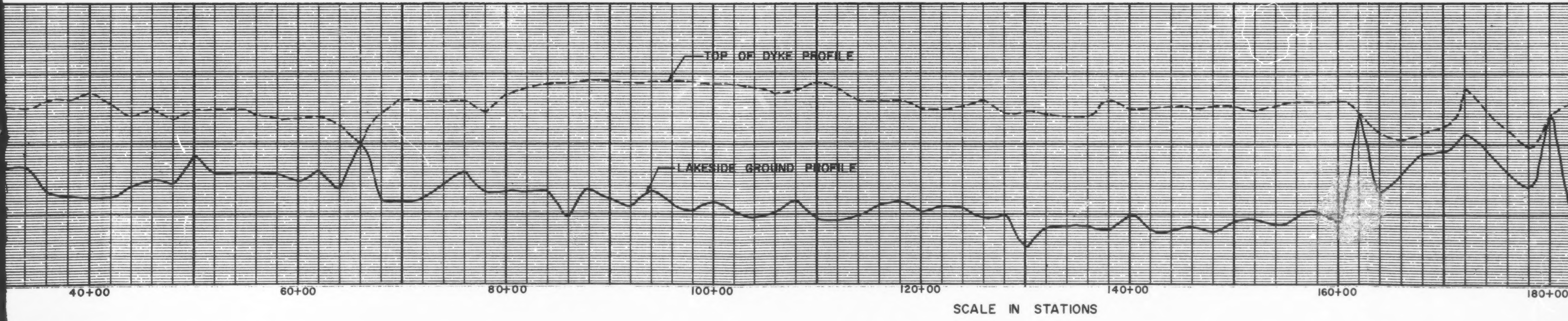
39-2-42F
-115L

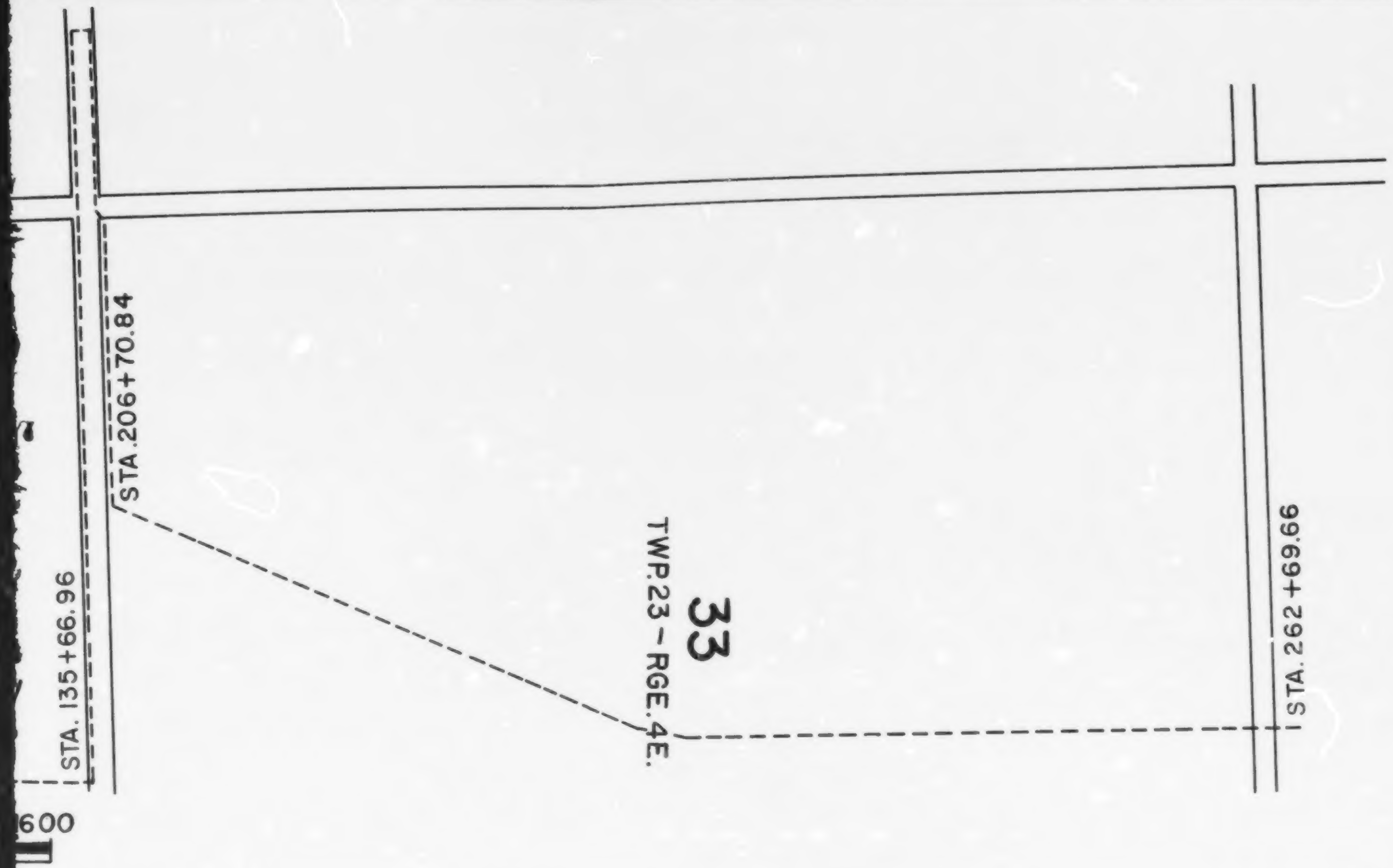
FIGURE 17

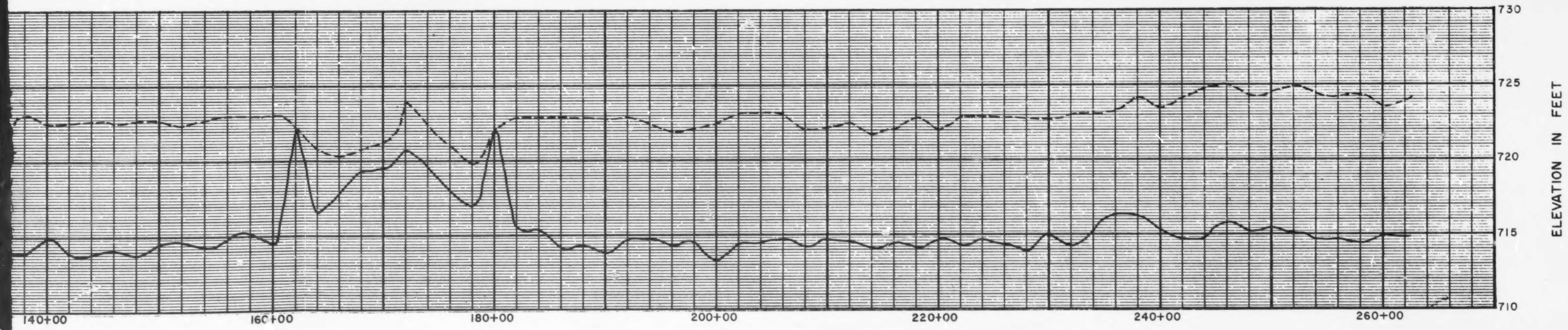
VILL


730
725
720
715
710
ELEVATION IN FEET
0+00
20+00
40+00


C. P. RLY.
STA.0+00 LINE 'B' = STA.3+00 LINE 'A'
VILLAGE OF RIVERTON
ICELANDIC RIVER
21
TWP.23 - RGE.4E.
STA.32+31.39
STA.78+04.03
234
28
TWP.23 - RGE.4E.
STA. 135+66.96
STA.206+70.84
33
TWP.23 - RGE.4E.
0
800
1600
SCALE IN FEET


TOP OF DYKE PROFILE
LAKESIDE GROUND PROFILE
40+00
60+00
80+00
100+00
120+00
140+00
160+00
180+00
SCALE IN STATIONS


STA. 206+70.84
STA. 135+66.96
33
TWP.23-RGE.4E.
STA. 262+69.66
4
TWP.24-RGE.4E.
600



FIELD BOOKS 39-2-43F
-116L

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

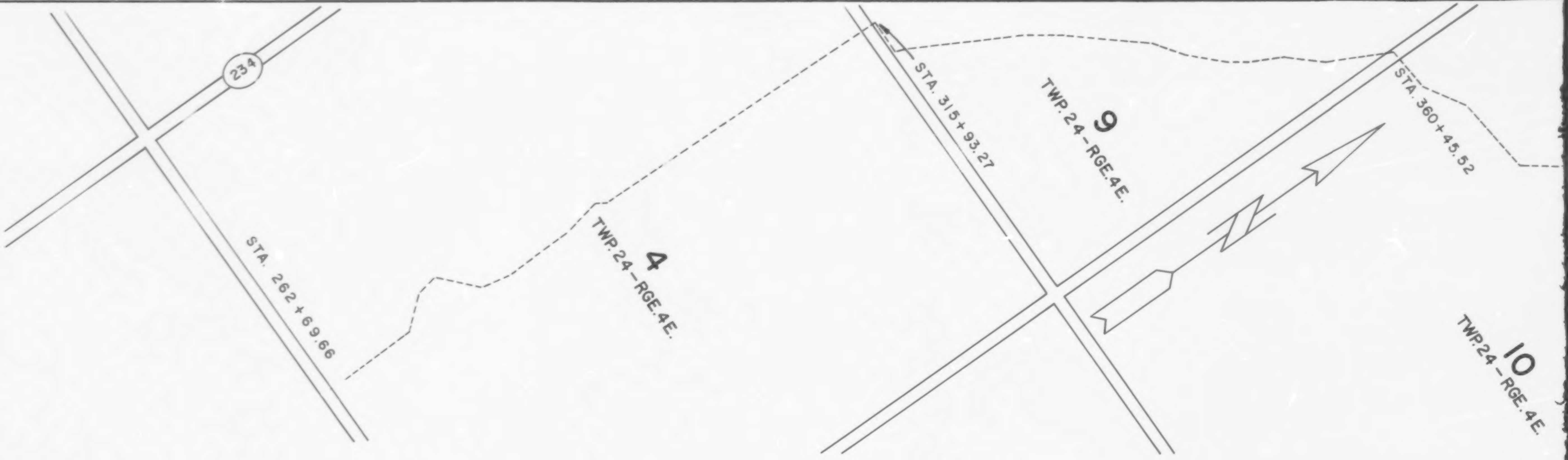
PREPARED	DRAWN T.M.	SUBMITTED	APPROVED
	CHECKED	DATE	DATE

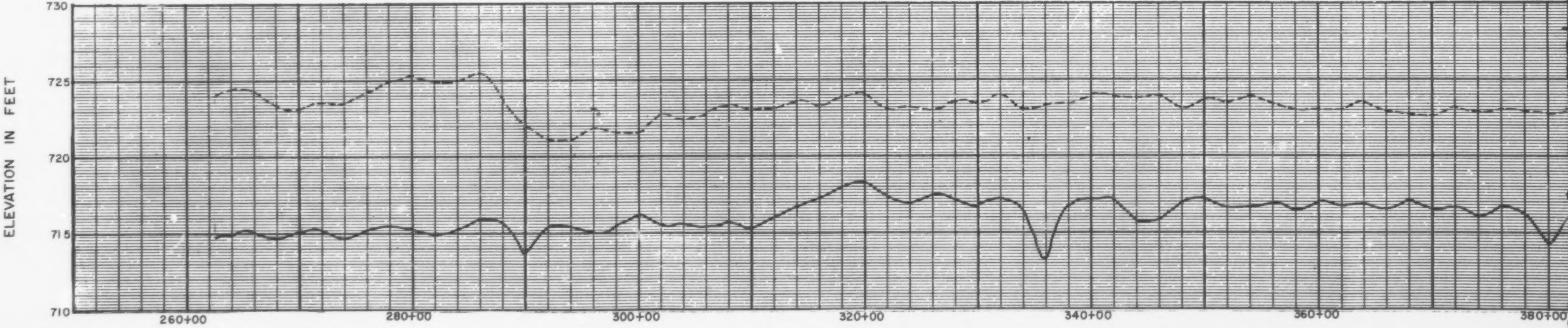
CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

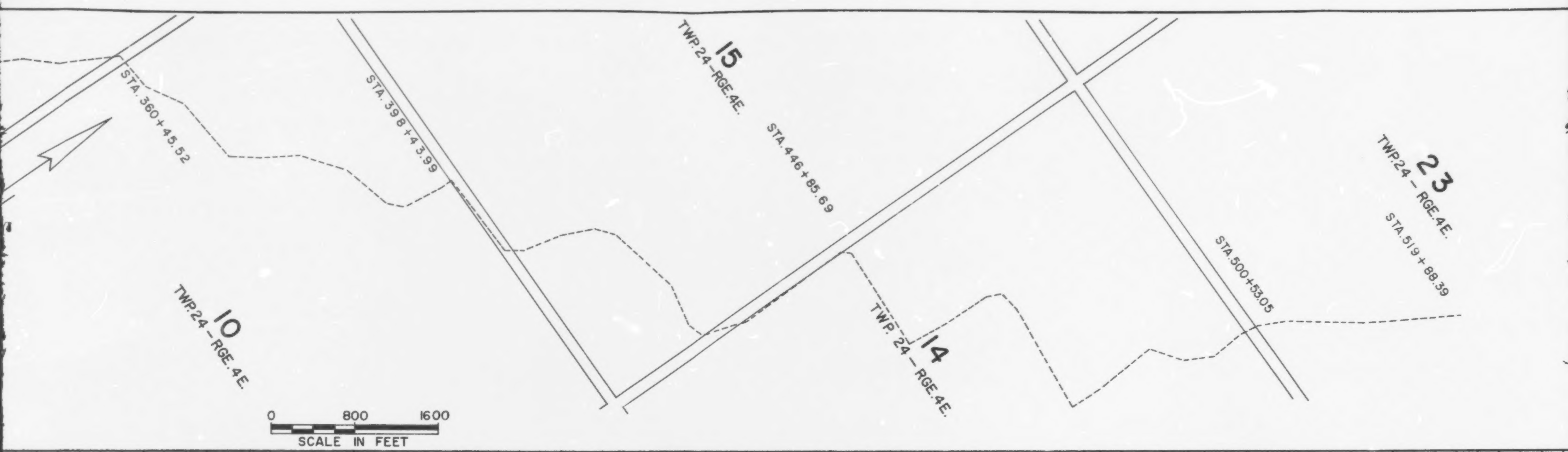
RIVERTON AND NORTH AREA DYKES

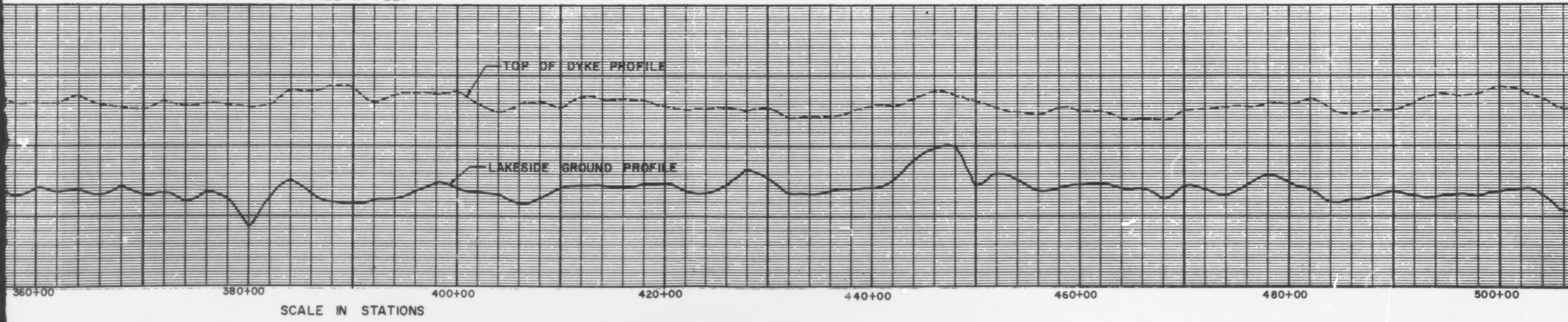
LAKE WINNIPEG TEMPORARY DYKING SYSTEM

SCALE AS SHOWN	DATE MAR./74	SHEET 18 OF 22	FILE NO. 39-2-1233


234
STA. 262+69.66
4
TWP.24-RGE.4E.
STA. 315+93.27
9
TWP.24-RGE.4E.
STA. 360+45.52
10
TWP.24-RGE.4E.


ELEVATION IN FEET
730
725
720
715
710
260+00
280+00
300+00
320+00
340+00
360+00
380+00


STA. 360+45.52
STA. 398+43.99
15
TWP.24-RGE.4E.
STA. 446+85.69
23
TWP.24 - RGE.4E.
STA. 519+88.39
STA. 500+53.05
14
TWP. 24 - RGE.4E.
10
TWP.24 - RGE.4E.
0
800
1600
SCALE IN FEET



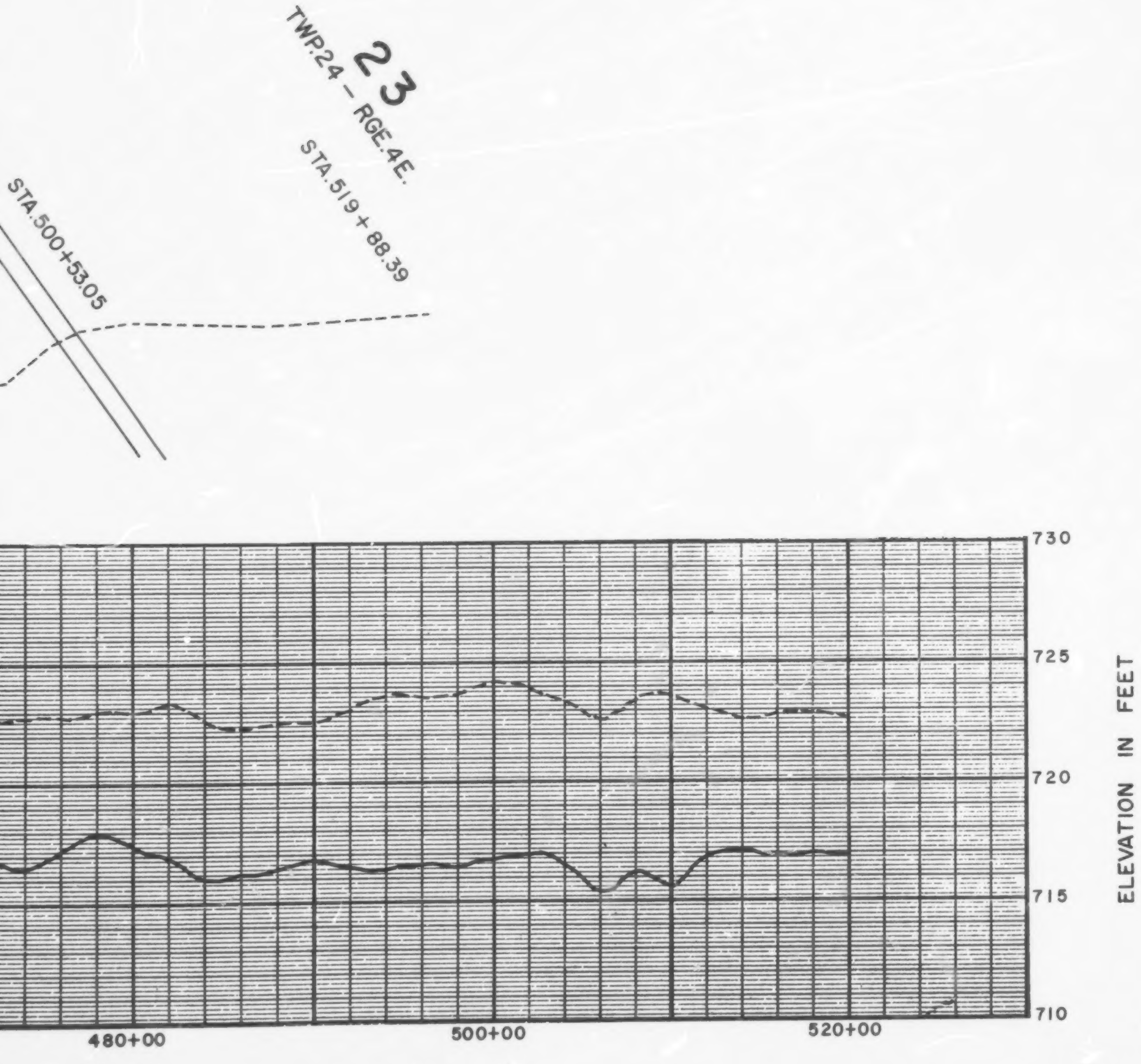
FIELD BOOKS 39-2-43 F, -44 F,
-116L, -117L

PROVINCE OF MANITOBA

DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MA

WATER RESOURCES BRANCH

PREPARED	DRAWN T.M.	SUBMITTED	APP
	CHECKED	DATE	DATE



23
TWP.24 – RGE.4E.
STA.519 + 88.39
STA.500+53.05
730
725
720
715
710
ELEVATION IN FEET
480+00
500+00
520+00

39-2-43 F,-44 F,
-116L,-117L

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

PREPARED	DRAWN T. M.	SUBMITTED	APPROVED
	CHECKED	DATE	DATE

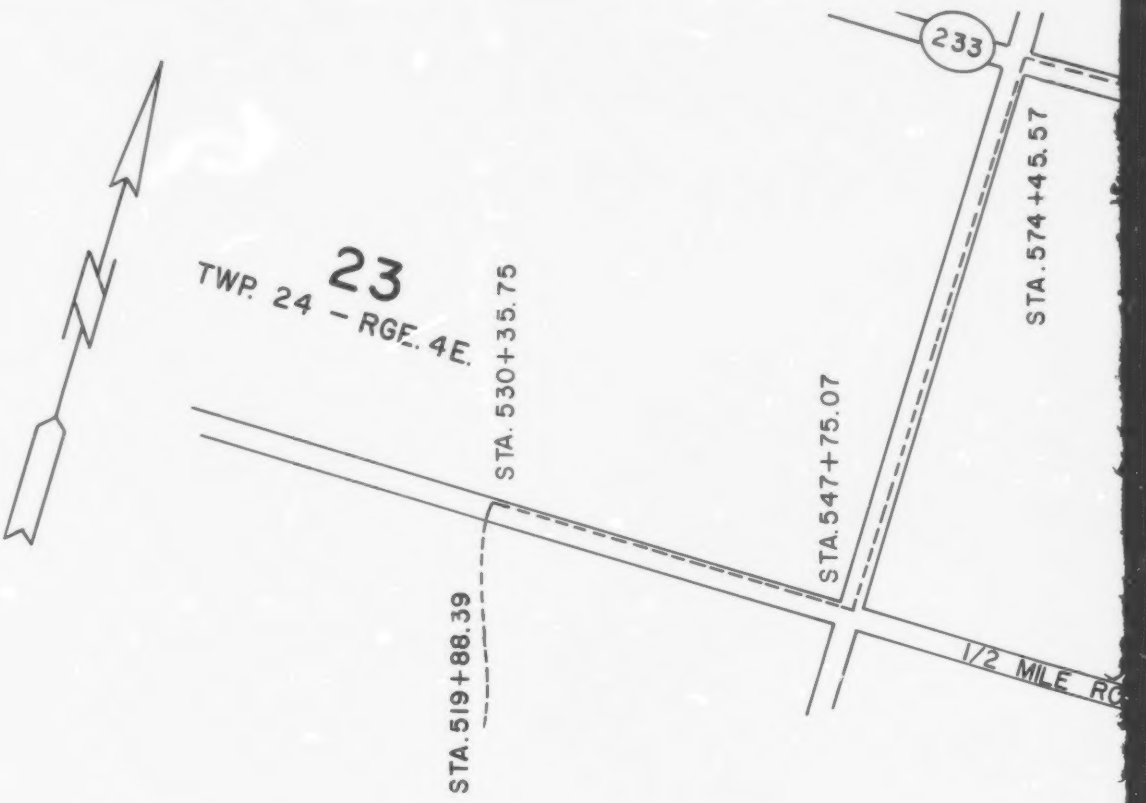
CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

RIVERTON AND NORTH AREA DYKES

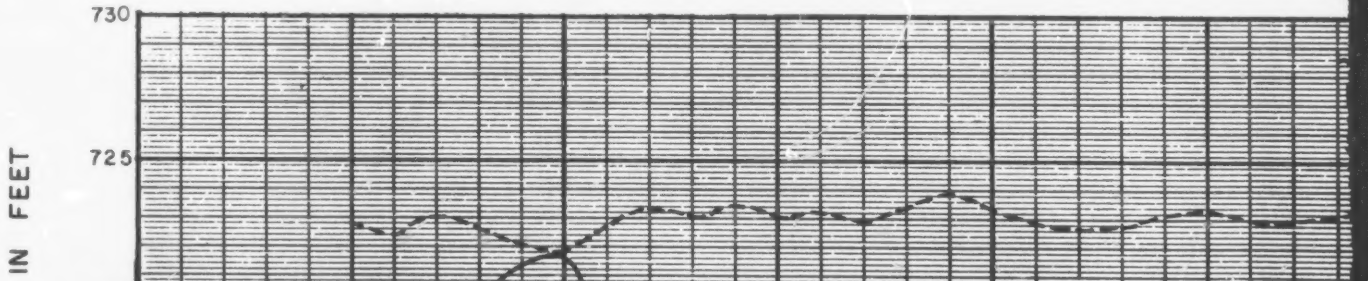
LAKE WINNIPEG TEMPORARY DYKING SYSTEM

SCALE	DATE	SHEET	FILE NO.
AS SHOWN	MAR./74	19 OF 22	39-2-1233

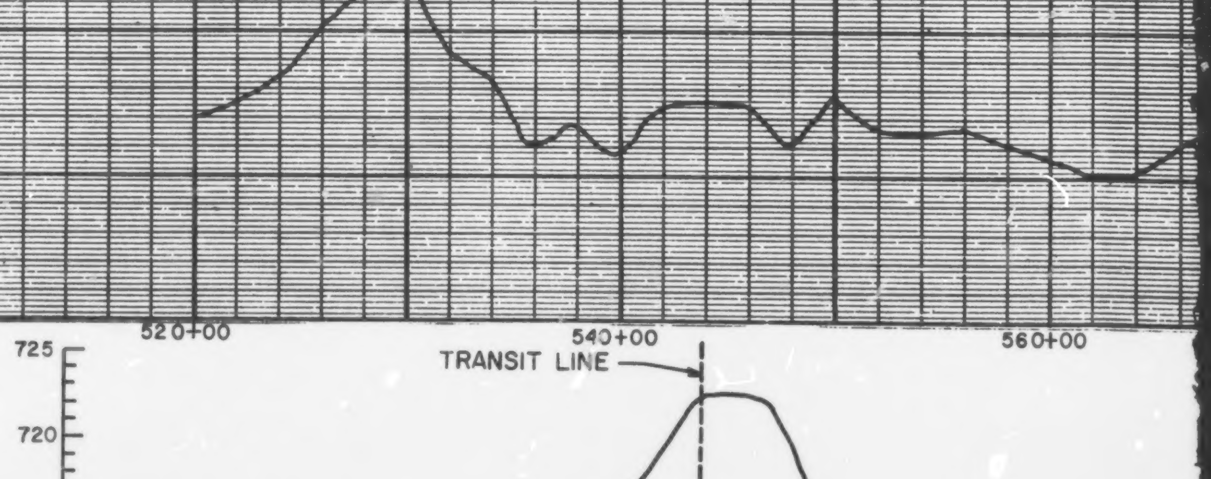
FIGURE 19



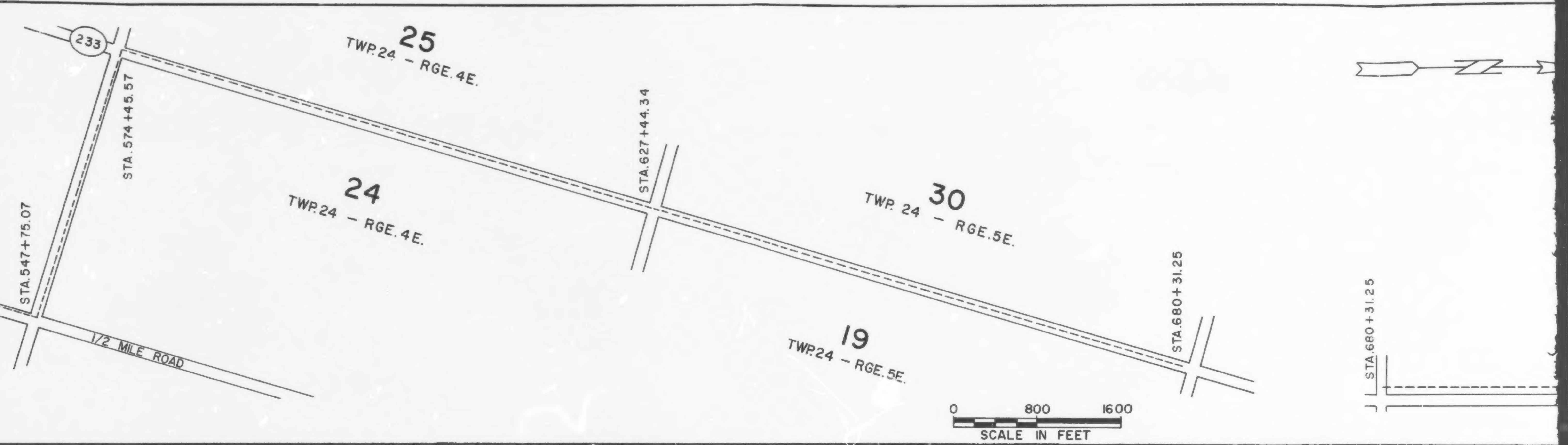
233
23
TWP. 24 - RGE. 4E.
STA. 530+35.75
STA. 547+75.07
STA. 574+45.57
STA. 519+88.39
1/2 MILE RO

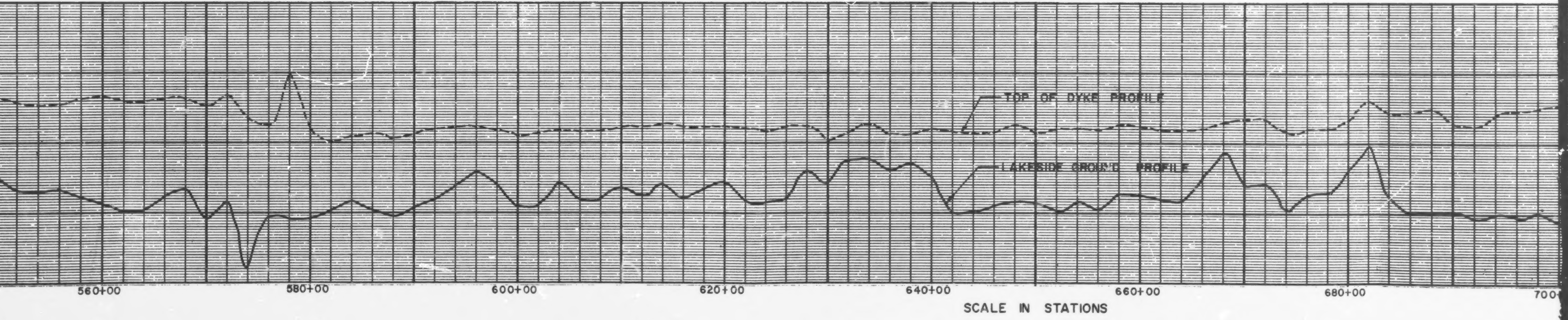


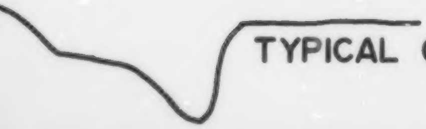
ELEVATION IN FEET
730
725
720
715
710
520+00
540+00
560+00



725
720
715
710
TRANSIT LINE
EXISTING CROSS-SECTION
TYPIC


233
25
TWP. 24 - RGE. 4E.
STA. 574+45.57
STA. 547+75.07
24
TWP. 24 - RGE. 4E.
1/2 MILE ROAD
STA. 627+44.34
30
TWP. 24 - RGE. 5E.
19
TWP. 24 - RGE. 5E.
STA. 680+31.25
STA. 680+31.25
0
800
1600
SCALE IN FEET

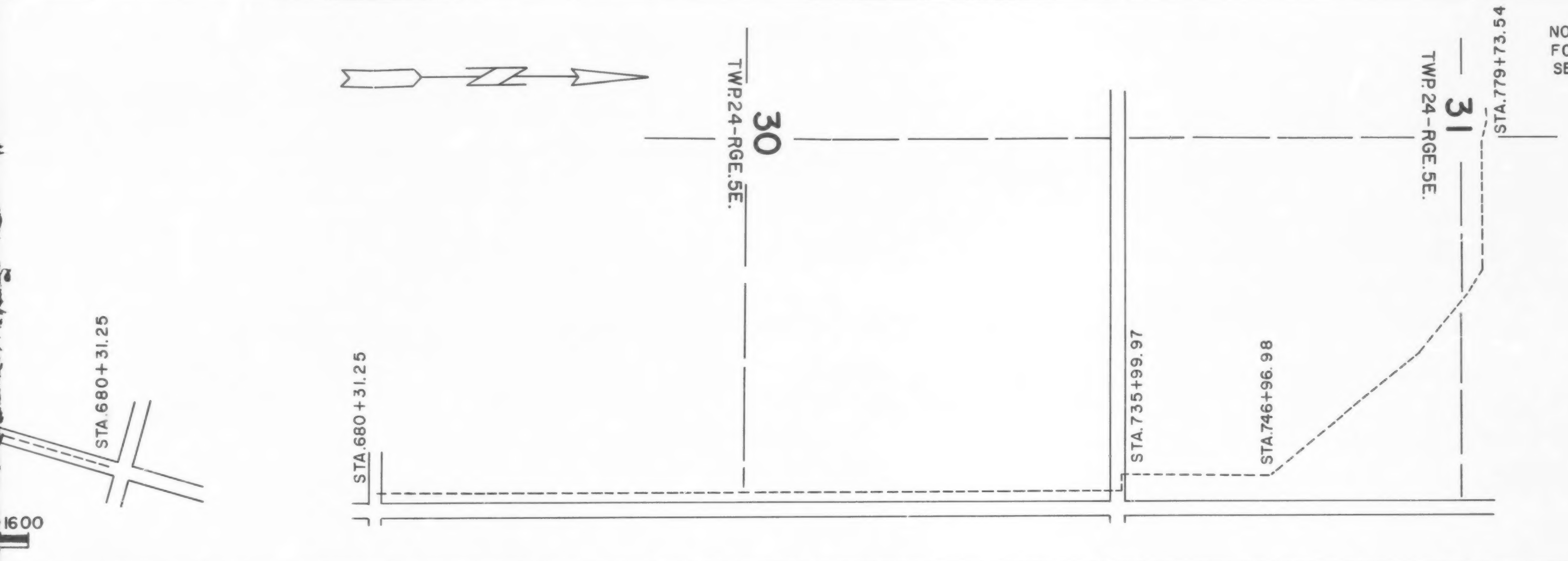


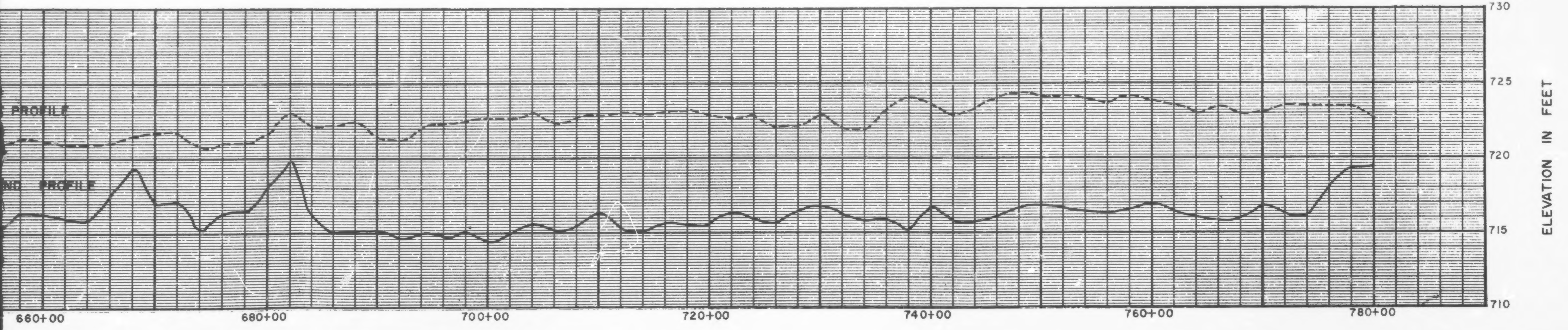


TYPICAL CROSS-SECTION TAKEN AT STA. 570+00

0
30
60
HORIZ. SCALE IN FEET

NOTE:
FOR CONTINUATION OF DYKE
SEE FIGURE 21


STA.680+31.25
1600
STA.680+31.25
30
TWP.24-RGE.5E.
STA.735+99.97
STA.746+96.98
31
TWP.24-RGE.5E.
STA.779+73.54



FIELD BOOKS 39-2-44F,
-117L

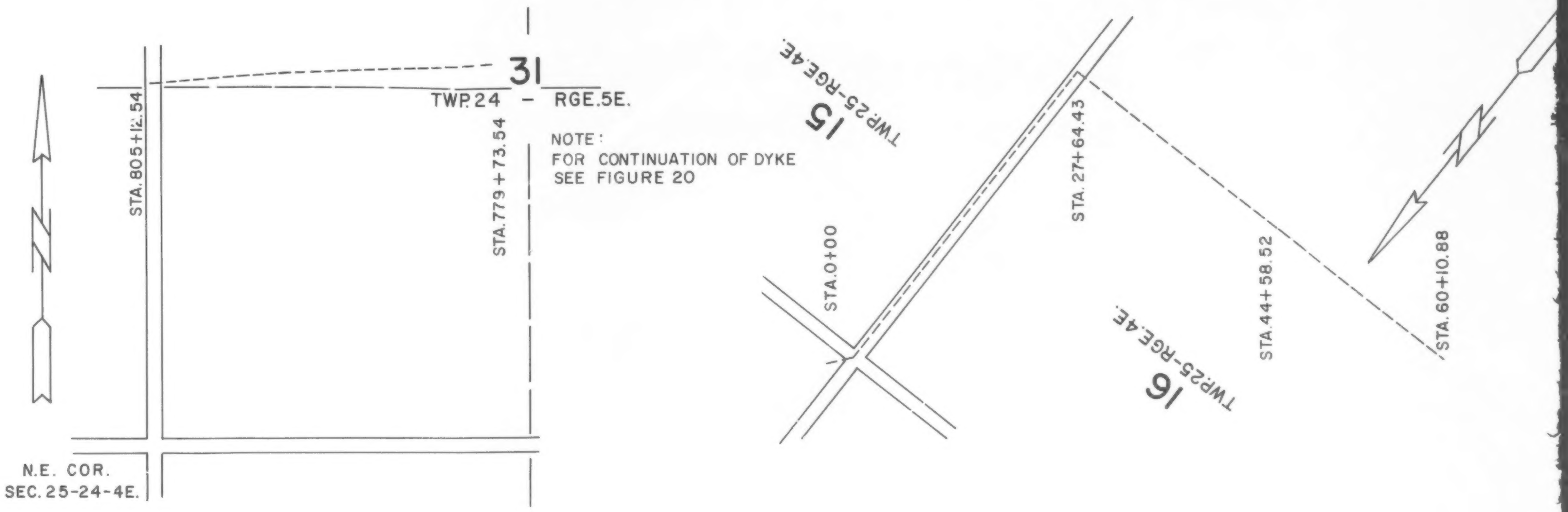
PROVINCE OF MANITOBA DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT WATER RESOURCES BRANCH			
PREPARED	DRAWN T. M. CHECKED	SUBMITTED DATE	APPROVED DATE

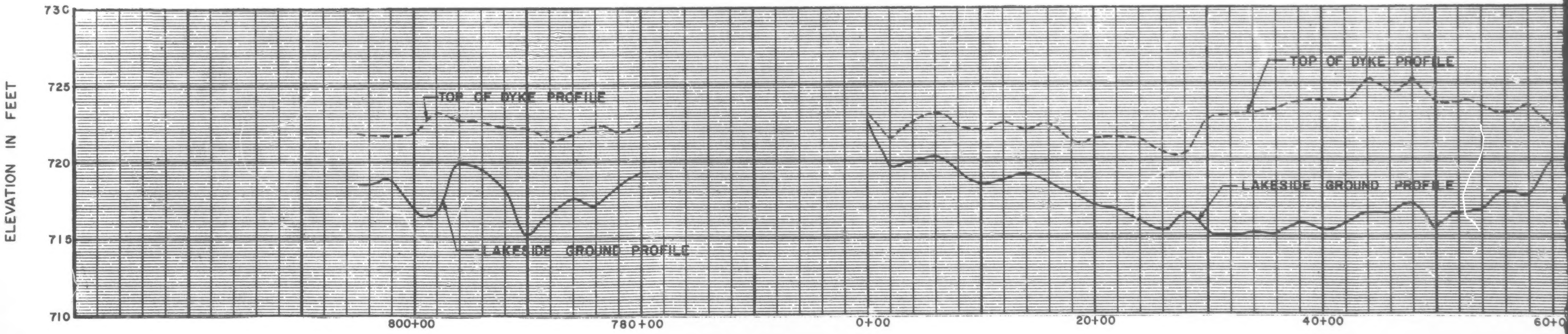
CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

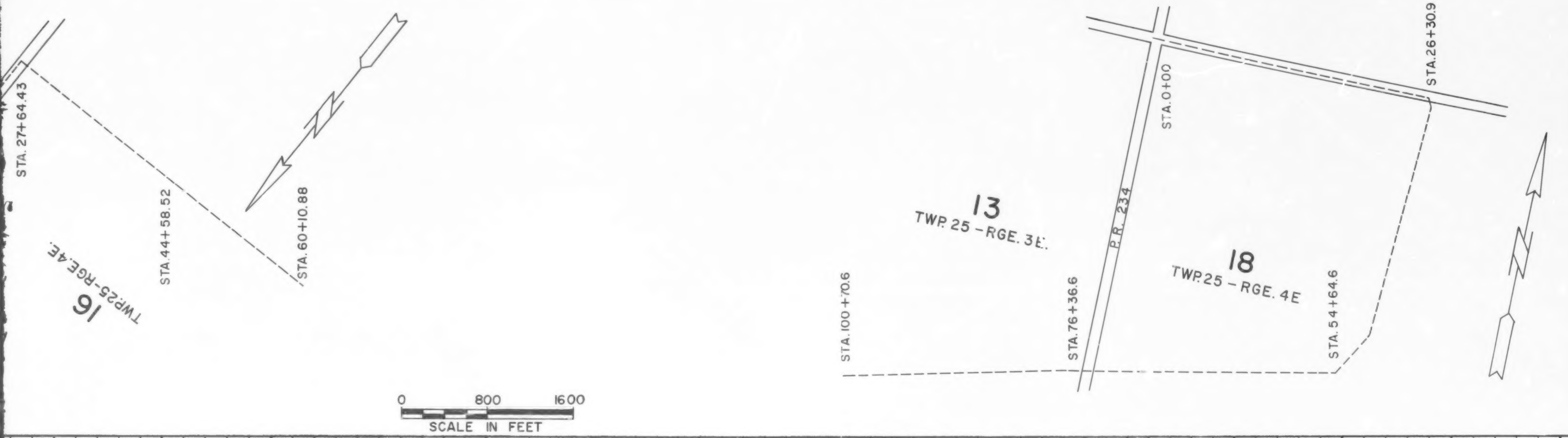
RIVERTON AND NORTH AREA DYKES
LAKE WINNIPEG TEMPORARY DYKING SYSTEM

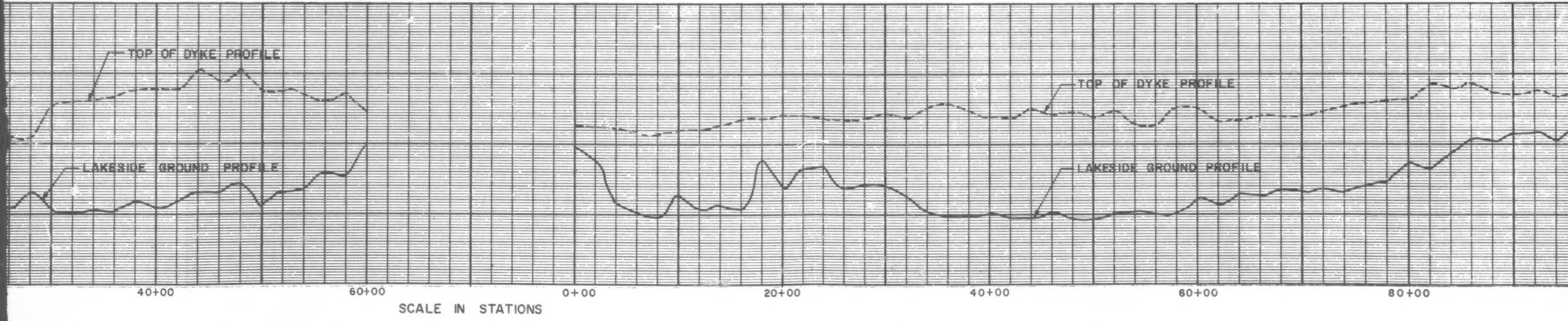
SCALE	DATE	SHEET	FILE NO.
AS SHOWN	MAR./74	20 OF 22	39-2-1233

FIGURE 20


31
TWP.24 - RGE.5E.
STA.805+12.54
STA.779+73.54
N.E. COR.
SEC.25-24-4E.
NOTE:
FOR CONTINUATION OF DYKE
SEE FIGURE 20
15
TWP.25-RGE.4E.
STA.0+00
STA.27+64.43
STA.44+58.52
16
TWP.25-RGE.4E.
STA.60+10.88

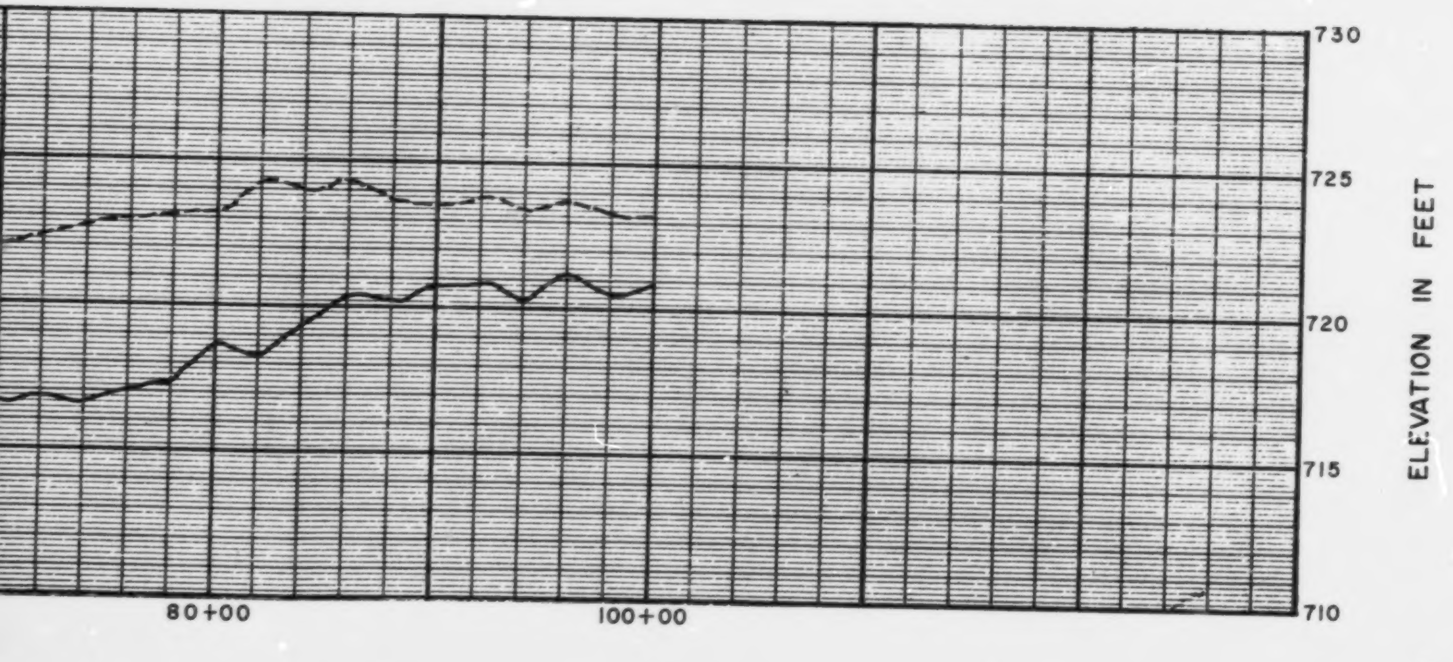

ELEVATION IN FEET
730
725
720
715
710
TOP OF DYKE PROFILE
LAKESIDE GROUND PROFILE
800+00
780+00
0+00
20+00
40+00
60+0
TOP OF DYKE PROFILE
LAKESIDE GROUND PROFILE


STA. 27+64.43
STA.44+58.52
STA. 60+10.88
16
TWP.25-RGE.4E.
13
TWP. 25 - RGE. 3E.
18
TWP. 25 - RGE. 4E
P.R. 234
STA. 0+00
STA.26+30.9
STA. 54+64.6
STA. 76+36.6
STA. 100+70.6
0
800
1600
SCALE IN FEET



FIELD BOOKS 39-2-44F,-45F,-48F,
-117L,-121L

PROVINCE
DEPARTMENT OF MINES, RESOUR
WATER RES
PREPARED
DRAWN T. M.
SUBM
CHECKED
DATE



39-2-44F,-45F,-48F,
-117L,-121L

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

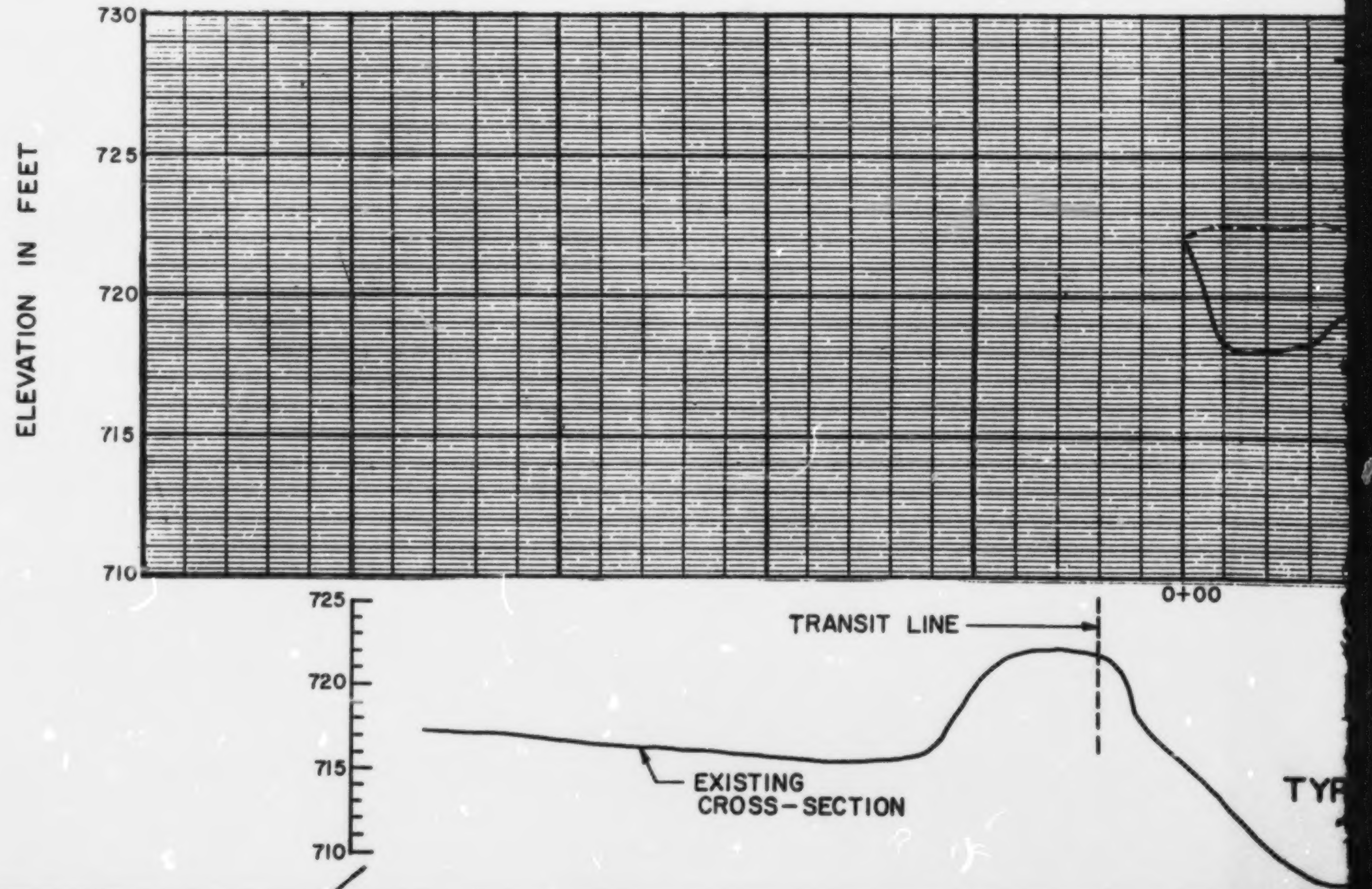
PREPARED	DRAWN T. M.	SUBMITTED	APPROVED
	CHECKED	DATE	DATE

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

WASHOW BAY AREA DYKES
LAKE WINNIPEG TEMPORARY DYKING SYSTEM

SCALE	DATE	SHEET	FILE NO.
AS SHOWN	MAR./74	21 OF 22	39-2-1233

FIGURE 21



730
725
720
715
710
ELEVATION IN FEET
0+00
725
720
715
710
TRANSIT LINE
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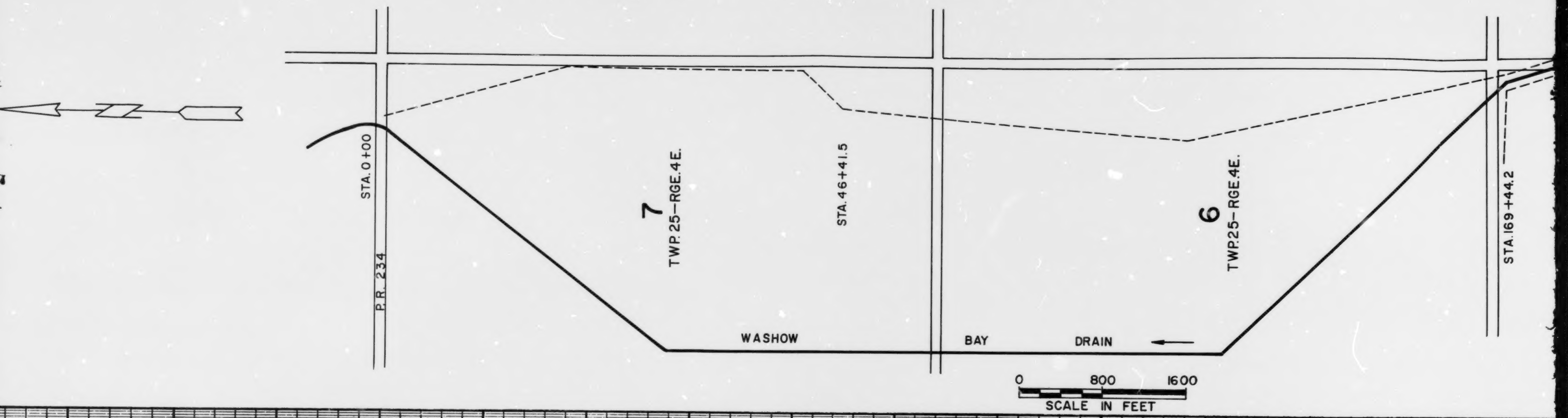
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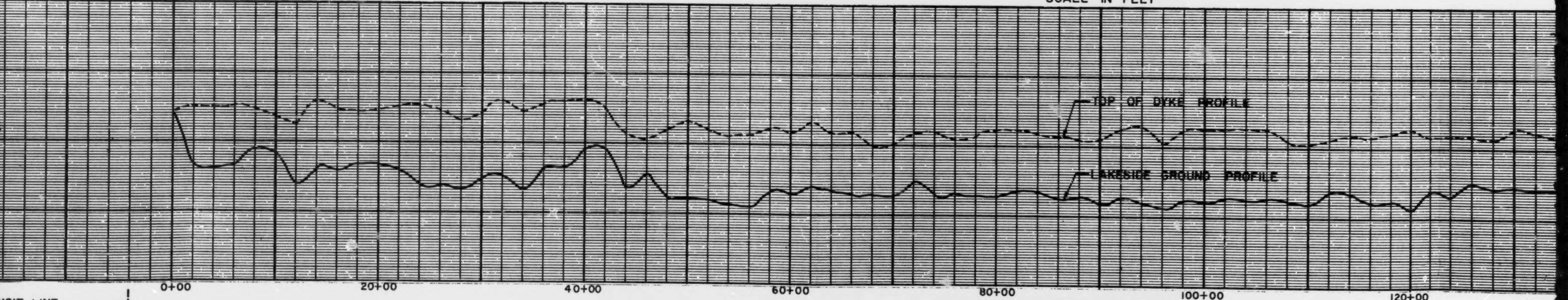

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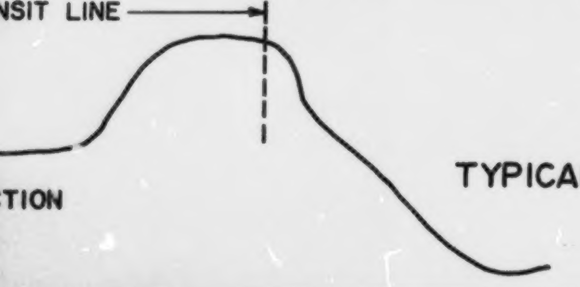
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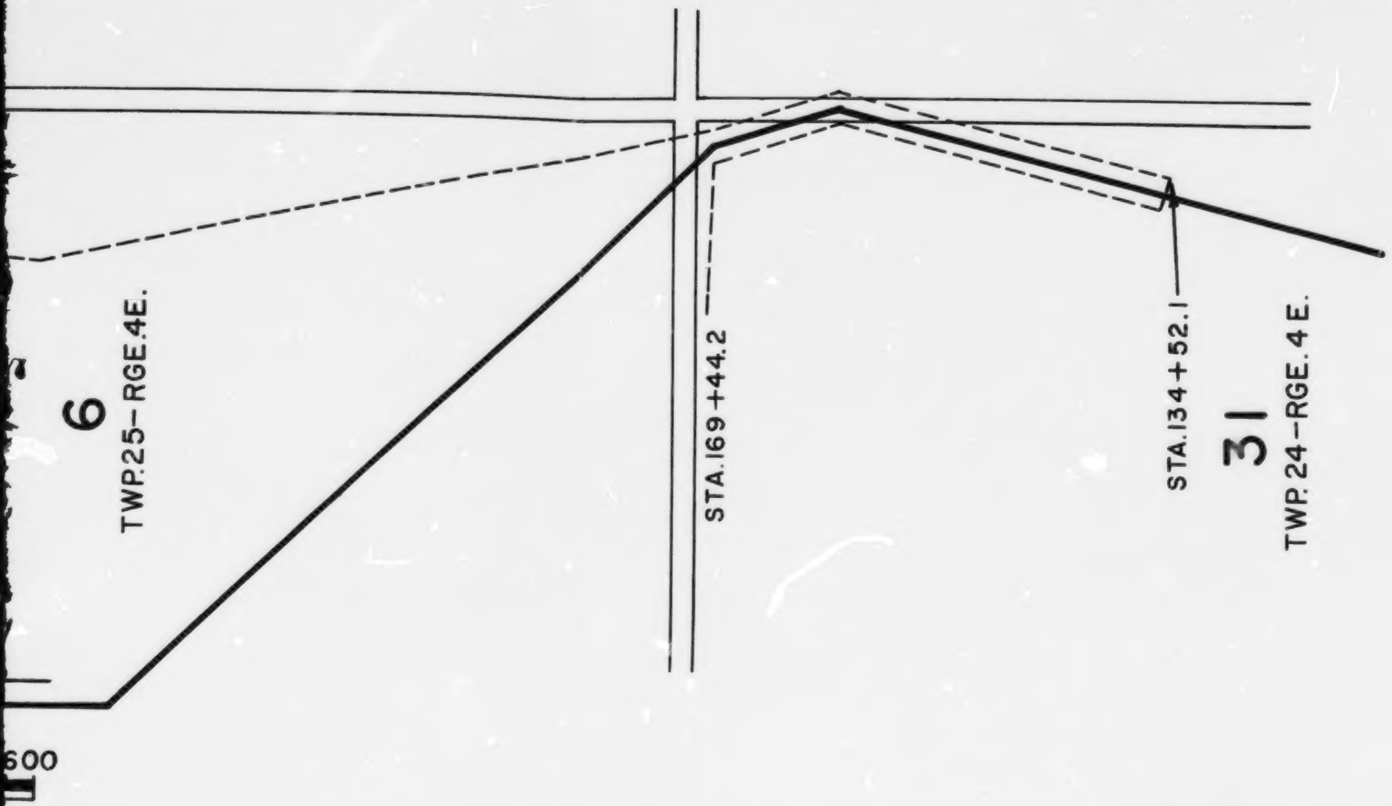
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TWP. 24–RGE. 4 E.
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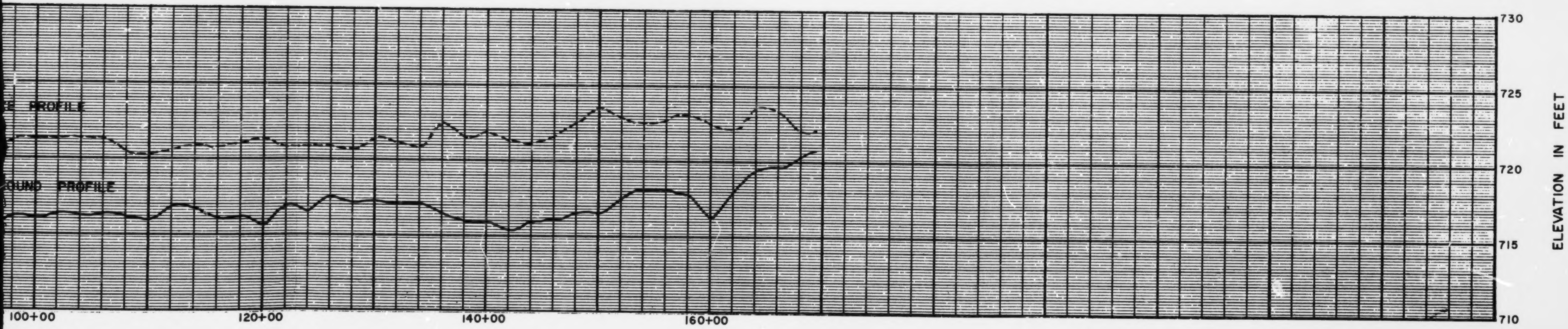

FIELD BOOKS 39-2-47F,
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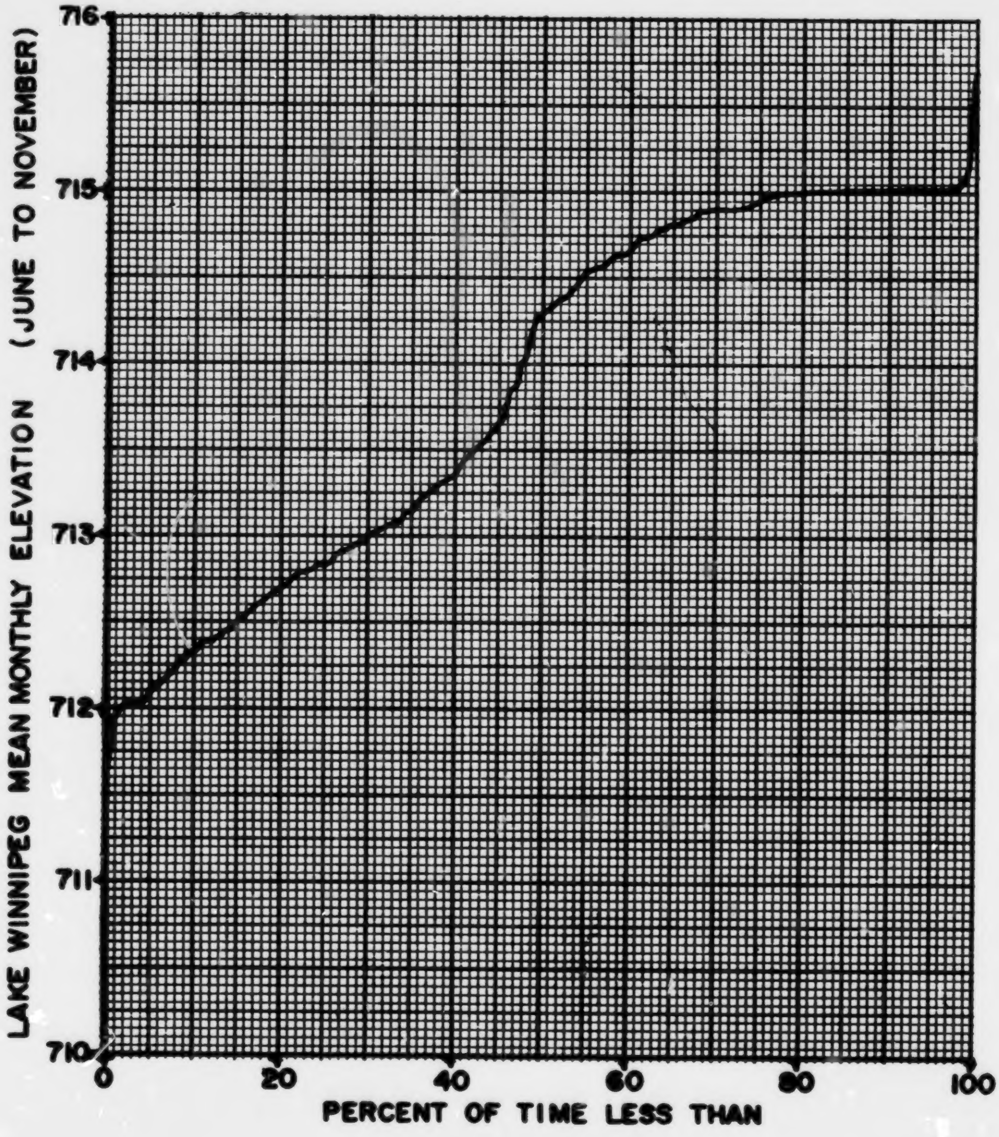
PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

PREPARED	DRAWN T. M.	SUBMITTED	APPROVED
	CHECKED	DATE	DATE

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

WASHOW BAY AREA DYKES
LAKE WINNIPEG TEMPORARY DYKING SYSTEM

SCALE AS SHOWN	DATE MAR./74	SHEET 22 OF 22	FILE NO. 39-2-1233



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SEQUENCE GIJA ITER 3
CRD 30,000 CFS/75 LWR/74
RANGE 711--715

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

PREPARED L. LEUNG
DRAWN P.G.
CHECKED
SUBMITTED
DATE
APPROVED
DATE

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

STAGE-DURATION CURVE
LAKE WINNIPEG
REGULATED CONDITIONS

SCALE AS SHOWN
DATE MAR/74
SHEET 9 OF 22
FILE NO. 39-2-1253

FIGURE 9

APPENDIX 4 - B

REAL PROPERTY ASSESSMENT - OUTLET LAKES AREA

REAL PROPERTY ASSESSMENT
OUTLET LAKES AREA

by

G. PINKOS
Planning Division, Water Resources Branch
Manitoba Department of Mines, Resources and Environmental Management
Winnipeg, Manitoba
November, 1973

for

THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SPECIAL NOTE

THE CONCLUSIONS AND RECOMMENDATIONS CONTAINED IN THIS APPENDIX ARE THOSE OF THE AUTHOR(S) AND ARE NOT NECESSARILY THE SAME AS THE CONCLUSIONS AND RECOMMENDATIONS OF THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD AS EXPRESSED IN THE SUMMARY REPORT AND THE TECHNICAL REPORT.

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Cross Lake Area 8

APPENDICES

APPENDIX A Structure Locations, Descriptions and Estimated Costs.

RECOMMENDATION

The Norway House and Cross Lake study areas were surveyed completely because these two locations have the greatest real property density in the Outlet Lakes Area.

There may be more structures that could be assessed scattered throughout the Outlet Lakes Area but the remoteness of these structures makes a survey costly. An appraisal of these structures could be made from a float-equipped aircraft during the open water season but the potential damages would be limited and would not affect total assessed damages materially. Detailed investigations are not recommended.

INTRODUCTION

The Lake Winnipeg, Churchill and Nelson Rivers Study Board, pursuant to the Terms of an Agreement made the 24th day of August, 1971, between the Governments of Canada and Manitoba, relating to the study of probable effects of Manitoba Hydro's projects on water and water related resource uses, has requested the Water Resources Branch to conduct certain investigations regarding Manitoba Hydro's hydro-electric power development schemes. This report contains the results of investigations in the Norway House and Cross Lake Areas concerning the assessment of real property that could be affected by the proposed hydro-electric power development.

In accordance with the Water Power Act; the Province of Manitoba issued Manitoba Hydro a supplementary interim license dated August 8, 1972 for the regulation of Lake Winnipeg between elevation 711 and 715,[1] Geodetic Survey of Canada Datum.

[1] All elevations quoted are above mean sea level, Geodetic Survey of Canada Datum.

At Norway House, the maximum recorded instantaneous water level was 717.03 at 5:30 p.m. on July 21, 1966. The corresponding mean monthly level was approximately 716.5. The water level at Norway House has been assumed to be approximately the same level as the water surface elevation on the southern portion of Playgreen Lake. The computed maximum mean monthly water level under regulation on the southern portion of Playgreen Lake occurs in June and is 715.4[2]. Therefore, the maximum expected water surface elevation in the Norway House Area is approximately 716.0.

The maximum recorded daily water elevation at Cross Lake was 685.21 on July 12, 1966. The corresponding mean monthly elevation was approximately 685.0. Under regulation, the maximum mean monthly level of 686.5 on Cross Lake occurs in July.

OBJECTIVES

The purpose of this report is to identify, describe and assess real properties which could be affected by high water and provide an estimate of the possible flood damages to real property associated with Lake Winnipeg regulation.

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[2] Water Resources Branch, December, 1972 "Water Level Information Lake Winnipeg and Outlet Lakes".

TERMS OF REFERENCE

This report contains an assessment of real property and possible damages to real property in two separate areas, the Norway House Area and the Cross Lake Area.

The water levels in Norway House and Cross Lake will be influenced by the operation of the control structure at Jenpeg.

STUDY AREAS

Norway House Area

This study area includes that portion of real property below elevation 720.0 on Mission Island, Fort Island, Towers Island, Kinusisipi, Rossville and the West Bank of the West Channel in the Norway House Settlement. These areas have a total shoreline distance of approximately 28.5 miles.

Cross Lake Area

This study area includes real property that is below elevation 690.0 in the following five communities of Cross Lake: Natamik Area, Mission Area, Wapak Area, Bay Area, and Saggitawak Area. The shoreline of Cross Lake Indian Reserves Number 19B and 19C was excluded from this survey because treacherous conditions over the ice made travel to these areas hazardous. However, based on a visual survey from the Natamik Area shoreline all the buildings sighted appeared to be above elevation 690.0.

METHODOLOGY

From January 29, 1973 to February 2, 1973 a reconnaissance survey of the Norway House Area and the Cross Lake Area was made by Water Resources Branch personnel working under the auspices of the Lake Winnipeg, Churchill and Nelson Rivers Study Board for the purpose of obtaining the inventory of real property that could be affected by the water power development scheme. The relevant data obtained from that survey is presented in Appendix "A" to this report.

The structure elevations in the Norway House Area were determined by using a hand level and by establishing as a bench mark, an ice elevation of 712.7 as obtained from a Water Survey of Canada water elevation of 712.2 on January 30, 1973 with 0.5 feet added to allow for the ice surface being above the water level.

The structure elevations in the Cross Lake Area were also determined by using a hand level and by establishing as a bench mark, an ice elevation of 679.7. This ice elevation was obtained from a Water Survey of Canada water elevation of 679.2 on February 1, 1973 with 0.5 feet added to adjust for the ice surface being above the water level.

The structural elevations in both these areas were taken as the ground elevation at the lowest point around buildings or as the deck elevation on docks and pedestrian bridges.

The elevations given in the structural inventory list should be rounded off to the nearest foot to allow for variations in the ice elevation which was used as a bench mark elevation. This variation in ice elevation is generally less than half a foot, therefore, the structure elevations should be reliable to the nearest foot.

The Appraiser's report in Appendix "A" of this report, presents reproduction "cost new" values for the buildings in both study areas. The reproduction "cost new" values do not represent the present physical value of the buildings but represents the cost of replacing buildings with comparable new facilities. It is necessary to subtract depreciation from the reproduction "cost new" values to obtain the present physical value of the buildings. It has been assumed that depreciation would range from 30% to 80% depending on the remaining useful life and conditions of the buildings.

Dock costs were not considered in the Appraiser's report, but estimated reproduction "cost new" values of the docks were calculated by Water Resources personnel. To obtain the present physical value of these docks, a depreciation factor of from 30% to 80% depending on the condition of the docks must be subtracted from the reproduction "cost new" values.

The summation of the reproduction "cost new" values for all buildings, docks, and pedestrian bridges are contained in the stage-real property assessment curves for both the study areas. The elevations of all the surveyed structures were rounded off to the nearest foot and the assessment values for these structures were summed and plotted at their individual elevations on the stage-real property assessment curves contained in Appendix "A".

The structures in both areas were categorized into six classifications in accordance with their observed condition in the field, and depreciation percentages were assigned to each classification as listed below:

Structural Conditions	Depreciation in Percent
Excellent	30
Very Good	40
Good	50
Fair	60
Poor	70
Very Poor	80

These depreciation factors were applied to the reproduction "cost new" values to obtain the present physical value for each structure.

Damage due to flooding is only a small percentage of the present physical value of buildings particularly if the flooding is to a relatively small depth and of limited duration. The ratios between damages and present physical values in percent for various depths of flooding were determined with the aid of Plate 32 in the "Report of the Royal Commission on Flood Cost Benefit" 1958, and they are as follows:

Depth of Flooding in Feet	Ratio between Damages and Present Physical Value in Percent
Ground Elevation -1	10
Main Floor Level 0	34
1	43
2	45
3	58
4	62
5	70
6	73

The present physical values, at the time of survey, of all the buildings up to a given stage were totalled and multiplied by the appropriate percentage for the depth of flooding at that stage. This product gives the damage value for the buildings at the particular stage. The percentage factors were not applied to docks because the structural damage is assumed to be equal to the present physical value if they are inundated.

The damage values for buildings and docks at a particular stage were totalled and plotted on a stage-damage curve for each study area.

OBSERVATIONS AND CONCLUSIONS

The field survey of real property was completed up to elevation 690.0 at Cross Lake and up to elevation 720.0 at Norway House. This should not be interpreted as meaning that under regulation flooding is expected at these levels in these particular areas. Flooding has occured under natural conditions at the lower water surface elevations indicated on the stage-real property assessment curves for the Cross Lake and Norway House Areas. However, an assessment as to whether or not flood damage occurs less frequently under regulated water levels as opposed to the natural water levels was not considered.

No provision has been made for land costs in the assessment of real property values for the Norway House or Cross Lake Areas.

Norway House Area

Between elevation 715.4 and 720.0 in the Norway House Area there are 95 buildings, 33 docks, 5 mobile trailers and 2 pedestrian bridges which totals 135 structures. The 95 buildings and 2 pedestrian bridges are all included in the stage-real property assessment and stage-damage curves. The 33 docks included in these curves are of a more permanent type of construction than the majority of docks that are damaged by ice and replaced almost annually. The 5 mobile trailers are excluded from the total damage costs in these curves because they can be moved to higher ground.

Below the highest expected water elevation of 716.0 in the Norway House study area there are 8 structures; 3 in poor condition, 4 in fair condition and 1 in good condition. A water elevation of 716.0 at Norway House would flood these 8 structures. Based on a reproduction "cost new" value of $10,000, the actual flood damage value is estimated to be $3,000 for a flood elevation of 716.0.

No roads were surveyed in the Norway House Area but several elevations were established for the center line of roads where these roads were located close to the shoreline. These roads would not be inundated by regulated water levels because they are above elevation 718.0.

Cross Lake Area

In the Cross Lake study area between elevation 682.0 and 690.3 there are 37 buildings, 13 docks and 5 pedestrian bridges. Only 35 buildings are included in the costs plotted on the stage-real property assessment curve and the stage-damage curve because structure number 17, a school, and structure number 27, a house, which are listed in the Cross Lake Area structures inventory in Appendix "A", are above elevation 690.0. The 13 docks listed in the structure inventory and included in the real property assessment and damage costs are only a fraction of the docks located in the study area but these particular 13 docks were selected because their type of construction is more permanent than the log constructed docks that are vulnerable to ice damage. Three of the five pedestrian bridges are not considered in the values in these curves bacause they are in poor condition and pedestrians are presently using a causeway which runs beside these pedestrian bridges.

Below the highest expected water elevation of 686.5 in the Cross Lake Area there are 28 structures: 5 in very poor condition, 6 in poor condition, 5 in fair condition and 12 in good condition. In the Cross Lake Settlement, a water elevation of 686.5 would flood these 28 structures. The reproduction "cost new" value is $40,000 and the estimated flood damage to these structures is $11,500.

The roads were not surveyed in the Cross Lake Area but approximate elevations of 685.0 were established on the two causeways that join the Mission Area and the Bay Area. No elevations were taken on the two causeways in the Saggitawak Area but their elevations would be approximately the same as the two surveyed causeways. Damages were not assessed for the limited period that the causeways would be out of service due to flooding.

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND
NELSON RIVERS STUDY BOARD

REAL PROPERTY ASSESSMENT
OUTLET LAKES AREA
APPENDIX A
STRUCTURE LOCATIONS, DESCRIPTIONS AND ESTIMATED COSTS

NOVEMBER, 1973

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NORWAY HOUSE AREA

General Location of Structures

The survey areas of Rossville, Fort Island, Kinusisipi, Mission Island, Towers Island, and the West Bank of the West Channel through the Norway House Settlement are identified on the site plan of Norway House which is Figure 2 in this Appendix.

The structures that are numbered in the Norway House Area structure inventory list are located in each of these communities as follows:

Community	Structure Numbers
Rossville	65 to 95
Fort Island	1 to 17, 22 to 37, 44, 53 to 64, 112 to 117, 123 to 126, 129 to 134
Kinusisipi	118 to 122
Mission Island	100 to 102, 107 to 111 127, 128
Towers Island	96 to 99, 103 to 106
West Bank of the West Channel through the Norway House Settlement	18 to 21, 38 to 43, 45 to 52

TABLE 1

NORWAY HOUSE AREA

STRUCTURE INVENTORY

Structure	Description	Construction	Dimensions (ft.)	Elevation (ft.)	Remarks
1	Manitoba Telephone Office	Wood frame, pitched roof	24.5 x 45.5	717.4	Good condition
2	Manitoba Telephone Shed	Wood frame, pitched roof	11 x 16	718.0	Good condition
3	Manitoba Telephone Shed	Wood frame, pitched roof	16.5 x 18.5	718.0	Good condition
4	Manitoba Telephone Building	Wood frame, pitched roof	18 x 19	718.5	Good condition
5	Garage	Wood frame, pitched roof concrete slab	20 x 24	719.4	Good condition
6	House	Wood frame, pitched roof full basement	28.5 x 36.5	719.4	Good condition
7	Dock	Crib	3.8 x 83 + 4.5 x 11	717.4	Poor condition
8	Accommodation Building	Wood frame, pitched roof full basement	32 x 72	718.4	Good condition
9	Shed	Wood frame, pitched roof	10.5 x 12.5	716.8	Good condition
10	Warehouse	Wood frame, pitched roof	18.5 x 28.5	716.8	Good condition
11	Dock	Crib	12 x 120 + 40 x 50	716.8	Fair condition
12	Hudson's Bay Dock	Crib	22.5 x 59.5	719.4	Good condition
13	Hudson's Bay Shed	Wood frame, pitched roof	14.5 x 24	719.4	Good condition
14	Post Office	Metal, pitched roof	28 x 36	718.4	Good condition
15	Dock	Crib	4 x 80 + 4 x 25	715.5	Poor condition
16	Municipal Information Centre	Wood frame, pitched roof	13 x 72.5 + 2(20 x 20)	717.9	New
17	Restaurant	Wood frame, pitched roof	24 x 56	718.9	Under construction
18	House	Wood frame, pitched roof	14.5 x 38	718.4	Poor condition
19	House	Wood frame, pitched roof	22.5 x 32.5	719.4	Good condition

TABLE 1 (con't)

NORWAY HOUSE AREA

STRUCTURE INVENTORY

Structure	Description	Construction	Dimensions (ft.)	Elevation (ft.)	Remarks
20	House	Wood frame, pitched roof	20 x 40	718.4	Poor condition (vacant)
21	Dock	Crib	4 x 60 + 4 x 26	718.9	Fair condition
22	Air Division Dock	Crib	13 x 100	718.4	Very good condition
23	Air Division Warehouse	Wood frame, pitched roof	20 x 84.5	718.6	Good condition
24	House	Wood frame, pitched roof	20 x 24	719.4	Fair condition
25	Playgreen Inn Dock	Crib	16 x 43.5	717.0	Poor condition
26	Playgreen Inn Shed	Wood frame, pitched roof	11 x 23	717.0	Fair condition
27	Playgreen Inn Shed	Wood frame, pitched roof, metal siding	11 x 23	717.0	Fair condition
28	Playgreen Inn Dock	Crib	10 x 110	717.9	Fair condition
29	Playgreen Inn Dock	Crib	20 x 22	719.4	Fair condition
30	Playgreen Inn Shed	Wood frame, pitched roof, metal siding	16 x 20	719.4	Poor condition
31	Dock	Post	7 x 142	718.0	Good condition
32	Centennial Hall	Wood frame, pitched roof	32.5 x 60.5	719.9	Good condition
33	Centennial Hall Dock	Crib	4 x 174 + 4 x 22	717.9	Good condition
34	Trailer	Metal	12 x 56.5	719.4	Portable
35	Aero Trades Dock	Post	4 x 69	718.7	Good condition
36	Dock	Crib	4 x 100	718.4	Fair condition
37	Pedestrian Bridge	Crib	8 x 250	716.0	Poor condition
38	House	Wood frame, pitched roof full basement	24 x 36	720.0	Good condition
39	House	Wood frame, pitched roof, full basement	24 x 40	721.0	Good condition

TABLE 1 (con't)

NORWAY HOUSE AREA

STRUCTURE INVENTORY

Structure	Description	Construction	Dimensions (ft.)	Elevation (ft.)	Remarks
40	Dock	Crib	6 x 70 + 8 x 11	717.4	Fair condition
41	Building	Log	14 x 20	718.5	Poor condition
42	Warehouse	Wood frame, pitched roof	16.5 x 26	718.4	Very poor condition (vacant)
43	Dock	Crib	8 x 39	716.4	Fair condition
44	Northern Affairs Dock	Piles	16 x 107 + 16 x 41.5	718.2	Excellent condition
45	House	Wood frame, pitched roof	20 x 22	718.8	Poor condition
46	Dock	4 inch diameter posts	4 x 70	715.4	Fair condition
47	House	Wood frame, pitched roof	30 x 32	719.3	Very poor condition (vacant)
48	Dock	4 inch diameter posts	4 x 35	717.4	Poor condition
49	House	Wood frame, pitched roof	24 x 28	718.0	Fair condition
50	Shed	Wood frame, pitched roof	12.5 x 14.5	718.4	Poor condition
51	Dock	4 inch diameter posts	3 x 20	717.4	Fair condition
52	Dock	4 inch diameter posts	4 x 45	716.1	Poor condition
53	Dock	Crib	12 x 200	717.4	Fair condition with seaward end damaged
54	Warehouse	Wood frame, pitched roof	24.5 x 32	717.9	Good condition
55	Dock	Crib	9 x 25.5	717.4	Good condition
56	Energy, Mines & Resources Warehouse	Wood frame, pitched roof	16.5 x 24.5	717.9	Good condition

TABLE 1 (con't)

NORWAY HOUSE AREA

STRUCTURE INVENTORY

Structure	Description	Construction	Dimensions (ft.)	Elevation (ft.)	Remarks
57	Energy, Mines & Resources Warehouse	Wood frame, pitched roof	20.5 x 36	717.9	Good condition
58	Energy, Mines & Resources Dock	Crib	13.5 x 91.5	717.4	Good condition
59	Air Division Building	Wood frame, pitched roof	24 x 95.5	720.7	New
60	House	Wood frame, pitched roof	35 x 36.5	718.3	Fair condition
61	Garage and shed	Wood frame, pitched roof	16 x 36	716.8	Fair condition
62	Renewable Resources Shed	Wood frame, pitched roof	12.5 x 16.5	718.4	Good condition and easily moved
63	Renewable Resources Shed	Wood frame, pitched roof	8.5 x 10.5	718.4	Good condition and easily moved
64	Renewable Resources Dock	Crib	10 x 41 + 10 x 22	716.7	Good condition
65	Federal Government Dock	Crib	15 x 90 + 15 x 60	715.4 + 718.1	Good condition
66	House	Wood frame, pitched roof	16.5 x 26.5	718.8	Poor condition
67	House	Wood frame, pitched roof	24.5 x 40	719.8	Good condition
68	House	Wood frame, pitched roof	19 x 31.5	719.8	Poor condition
69	Shed	Wood frame, pitched roof	20 x 30.5	717.4	Very poor condition (vacant)
70	Hudson's Bay Dock	Crib	6 x 161 + 6 x 15.5	717.1 + 718.4	Poor condition
71	Hudson's Bay Workshop	Wood frame, pitched roof	14.5 x 24.5	718.4	Good condition
72	Hudson's Bay Warehouse	Wood frame, pitched roof	26 x 40.5	719.4	Good condition
73	United Church Dock	Crib	24.5 x 47.5	716.9	Fair condition

TABLE 1 (con't)

NORWAY HOUSE AREA

STRUCTURE INVENTORY

Structure	Description	Construction	Dimensions (ft.)	Elevation (ft.)	Remarks
74	United Church Shed	Wood frame, pitched roof	20.5 x 20.5	719.0	Good condition
75	Shed	Wood frame, pitched roof	11 x 15.5	717.0	Poor condition
76	Indian Affairs Pump House	Concrete block, flat roof, concrete wet well	21.5 x 53.5	719.4	Good condition
77	Building	Wood frame, pitched roof	22.5 x 32	718.0	Very poor condition (vacant)
78	Boathouse	Wood frame, pitched roof	30 x 70.5	718.8	Fair condition
79	Shed	Wood frame, pitched roof	20.5 x 33	718.8	Fair condition
80	Shed	Wood frame, pitched roof	24.5 x 48.5	718.8	Fair condition
81	Dock	Crib	4750 sq. ft.	718.8	Fair condition
82	Shed	Wood frame, pitched roof	12.5 x 12.5	717.4	Fair condition
83	Workshop	Wood frame, pitched roof	27 x 48.5	718.4	Good condition
84	Warehouse	Wood frame, pitched roof	27 x 46.5 + 10 x 12.5	717.9	Good condition
85	Shed	Wood frame, pitched roof	17 x 40	718.9	Poor condition
86	Northern Affairs Dock	Crib, rock filled	12 x 167 + 24 x 16.5	719.4	Excellent condition
87	Pedestrian Bridge	Crib	10.5 x 123	716.7	Fair condition
88	House	Wood frame, pitched roof	23 x 25	717.8	Poor condition
89	House	Wood frame, pitched roof	24.5 x 33	718.9	Good condition
90	House	Wood frame, pitched roof	16 x 18	719.0	Fair condition
91	House	Wood frame, pitched roof	20.5 x 24.5	718.8	Fair condition
92	House	Wood frame, pitched roof	19.5 x 21.5 + 10 x 12	717.2	Fair condition
93	House	Wood frame, pitched roof	14 x 16 + 8 x 12.5	718.2	Very poor condition
94	House	Wood frame, pitched roof	20.5 x 26 + 7 x 14	718.2	Good condition

TABLE 1 (con't)

NORWAY HOUSE AREA

STRUCTURE INVENTORY

Structure	Description	Construction	Dimensions (ft.)	Elevation (ft.)	Remarks
95	House	Wood frame, pitched roof	24.5 x 38.5	718.2	Good condition
96	Classroom	Wood frame, pitched roof	24.5 x 34.5	717.0	Good condition (vacant)
97	Shed	Wood frame, pitched roof	12.5 x 24.5	717.5	Good condition
98	House	Wood frame, pitched roof	31.5 x 23.5	718.0	Fair condition
99	Shack	Log	14 x 18	718.0	Very poor condition (vacant)
100	Dock	Posts	3.5 x 96	717.8	Fair condition
101	House	Wood frame, pitched roof	18.5 x 20.5	717.9	Poor condition (vacant)
102	House	Wood frame, pitched roof	25 x 32	717.9	Fair condition
103	Shed	Log	17 x 20	717.7	Poor condition
104	House	Wood frame, pitched roof	16 x 18	717.6	Fair condition
105	House	Wood frame, pitched roof	16 x 16	717.6	Fair condition
106	House	Wood frame, pitched roof	24.5 x 26.5	717.6	Poor condition
107	House	Wood frame, pitched roof	22.5 x 33	719.5	Poor condition
108	Shed	Log	9 x 12.5	716.7	Poor condition
109	House	Wood frame, pitched roof	16.5 x 25	717.9	Fair condition
110	House	Wood frame, pitched roof	16.5 x 25	717.4	Poor condition
111	Anglican Mission Dock	Crib	14 x 145	717.9 + 716.9 +	
112	House	Wood frame, pitched roof	19 x 28.5	719.6	Poor condition
113	Garage	Wood frame, pitched roof	16 x 28	719.4	Very poor condition (vacant)
114	Garage	Log	16 x 28	719.4	Fair condition
				719.4	Poor condition

TABLE 1 (con't)

NORWAY HOUSE AREA

STRUCTURE INVENTORY

Structure	Description	Construction	Dimensions (ft.)	Elevation (ft.)	Remarks
115	Roman Catholic Church Shed	Wood frame, pitched roof	24 x 35.5	716.0	Fair condition
116	Roman Catholic Church Dock	Crib	1460 sq. ft.	716.0	Fair condition
117	House	Wood frame, pitched roof	19 x 32.5	718.4	Fair condition
118	House	Wood frame, pitched roof	20.5 x 36	718.4	Fair condition
119	Coffee Shop	Wood frame, pitched roof	24 x 24	717.4	Good condition (new)
120	Recreation Building	Wood frame, pitched roof	18 x 52.5	717.2	Fair condition
121	House	Wood frame, pitched roof	24 x 26	718.5	Good condition (new)
122	Shed	Log	19.5 x 28	718.5	Very poor condition
123	House	Wood frame, pitched roof	24.5 x 38	719.4	Good condition
124	Shed	Log	16 x 18	718.2	Poor condition
125	House	Wood frame, pitched roof	20.5 x 22.5	718.6	Poor condition
126	House	Wood frame, pitched roof	24 x 32	718.6	Fair condition
127	Shelter	Wood frame, sloped roof	2 (8 x 12)	716.8	on skips
128	Dock	Crib	3 x 49	717.3	Good condition
129	Dock	Crib	10 x 52 + 8 x 22	719.6	Fair condition
130	Warehouse	Wood frame, pitched roof	24 x 48.5	717.2	Temporary storage poorly constructed
131	Garage	Wood frame, pitched roof	16 x 36	717.5	Temporary storage poorly constructed
132	Trailers	Metal on wood cribs	2 (10 x 40.5)	717.5	Portable
133	Trailer	Metal	10 x 30	717.4	Portable
134	Trailer	Metal	12 x 34.5	717.4	Portable

CROSS LAKE AREA

General Location of Structures

The Mission Area, Bay Area, Wapak Area, Natamik Area, and Saggitawak Area are identified on the site plan of Cross Lake which is Figure 3 in this Appendix.

The structures that are numbered in the Cross Lake Area structure inventory list are located in each of these communities as follows:

Community	Structure Numbers
Mission Area	1 to 8
Bay Area	9 to 16
Wapak Area	17 to 24
Natamik Area	25 to 36
Saggitawak Area	37 to 55

TABLE 2

CROSS LAKE AREA

STRUCTURE INVENTORY

Structure	Description	Construction	Dimensions (ft.)	Elevation (ft.)	Remarks
1	Sawmill	Wood frame, pitched roof	27 x 70.5	686.0	Poor condition
2	Roman Catholic Mission Boat House	Wood frame, pitched roof	22 x 68	682.7	Poor condition
3	Roman Catholic Mission Shed	Wood frame, pitched roof	20.5 x 30.5	685.3	Good condition
4	Roman Catholic Mission Dock	Crib	25 x 39 + 8.5 x 61	685.3	Good condition
5	House	Wood frame, pitched roof	24.5 x 32.5	689.7	Good condition
6	House	Log	19 x 23	688.7	Poor condition
7	Shed	Wood frame, pitched roof	16.5 x 25.5	683.2	Poor condition
8	Pedestrian Bridge	4 inch diameter posts	—	684.5	Very poor condition and replace by new road.
9	House	Log	22.5 x 24	688.5	Poor condition
10	Shed	Log	11 x 12.5	688.5	Poor condition
11	Dock	Crib	10 x 54	683.9	Fair condition
12	Hudson's Bay Dock	Crib	9 x 300	686.1	Good condition
13	Wharf	Crib	3870 sq. ft. 150 sq. ft.	686.9 682.6	Good condition Good condition
14	Shed	Wood frame, pitched roof	12 x 16	686.9	Good condition
15	Air Division Dock	Crib	6 x 150	685.2	Good condition
16	Pedestrian Bridge	Crib	—	686.2	Poor condition and replace by new road
17	School	Trailer units joined together	3 (59 x 84.5) + 2 (9 x 30.5)	690.1	New
18	Shed	Log	11.5 x 14.5	689.9	Poor condition
19	Shed	Log	10 x 14.5	688.5	Poor condition

TABLE 2 (con't)

CROSS LAKE AREA

STRUCTURE INVENTORY

Structure	Description	Construction	Dimensions (ft.)	Elevation (ft.)	Remarks
20	Dock	Crib	8.5 x 62	686.1	Good condition
			8.5 x 18	683.7	Good condition
21	House	Wood frame, pitched roof	25 x 30.5	687.9	Good condition
22	House	Log	17.5 x 21.5	688.9	Poor condition
23	House	Wood frame, pitched roof	20 x 36	687.9	Fair condition
24	Shed	Wood frame, pitched roof	12 x 16	688.6	Good condition
25	Pedestrian Bridge	Crib	9.5 x 1090	688.3	Good condition
26	Pedestrian Bridge	Crib	12 x 372	685.0	Fair condition
27	House	Wood frame, pitched roof	24.5 x 40.5	690.3	Fair condition
28	House	Wood frame, pitched roof	17.5 x 22	689.1	Fair condition
29	Shed	Log	17.5 x 31	686.9	Poor condition
30	House	Wood frame, pitched roof	24.5 x 29	688.9	Good condition
31	Dock	Crib	8.5 x 50	687.1	Good condition
			8.5 x 20.5	683.9	Good condition
32	Dock	Crib	6 x 28.5 +		
			6.5 x 21.5	685.0	Good condition
33	Shed	Wood frame, pitched roof	5 x 10	687.4	Poor condition
34	Shed	Wood frame, pitched roof	6.5 x 14	684.4	Very poor condition (vacant)
35	Shed	Log	13.5 x 14.5	684.7	Very poor condition (vacant)
36	Dock	Crib	7.5 x 59	685.1	Good condition
37	Dock	Crib	4 x 60	683.9	Fair condition
38	House	Wood frame, pitched roof	24.5 x 24.5	687.6	Good condition
39	Shed	Log	8 x 10	682.0	Very poor condition

TABLE 2 (con't)

CROSS LAKE AREA

STRUCTURE INVENTORY

Structure	Description	Construction	Dimensions (ft.)	Elevation (ft.)	Remarks
40	House	Wood frame, pitched roof	18.5 x 23	683.0	Poor condition
41	House	Log	13.5 x 17.5	683.0	Very poor condition
42	House	Wood frame, pitched roof	24.5 x 40.5	686.0	Good condition
43	Church Dock	Crib	8 x 165	685.2	Good condition
44	Warehouse	Wood frame, pitched roof	20.5 x 34.5	684.9	Fair condition
45	House	Wood frame, pitched roof	16 x 36.5	686.5	Fair condition
46	Church Warehouse	Wood frame, pitched roof	18 x 20	688.0	Good condition
47	Pedestrian Bridge	Crib	—	685.1	Poor condition and replaced by road
48	House	Wood frame, pitched roof	20 x 26	687.8	Good condition
49	House	Wood frame, pitched roof	20 x 30.5	689.4	Good condition
50	Dock	Crib	6 x 117	684.4	Fair condition
51	House	Wood frame, pitched roof	24.5 x 32.5	687.9	Good condition
52	House	Log	21.5 x 22	688.3	Very poor condition (vacant)
53	House	Wood frame, pitched roof	24.5 x 30.5	687.3	Good condition
54	Building	Log	8 x 14	687.3	Very poor condition
55	Dock	Crib	6 x 92	684.6	Good condition

APPRAISER'S REPORT

The report of the appraiser is contained in a letter from Mr. W. Slusar, Property Manager, Land Acquisition Branch, to Mr. W. A. Cook, Head, Hydraulic Section, Water Resources Branch, dated March 12, 1973. The full content of the letter follows:

"Further to your request dated February 22, 1973, attached hereto is a list showing the estimated reproduction cost new of buildings in the inventory report furnished me by your Branch.

Please note the estimated reproduction cost new is subject to the following condition:

1. The Appraiser did not have the opportunity to inspect any of the structures or buildings and based his opinion on the information furnished by your Branch.

As previously reported to you on November 15th, 1972, it was suggested that the present physical depreciated value would likely be in a range of 30% to 80% depending on construction, condition and remaining useful life of the building."

TABLE 3

REPRODUCTION COST NEW ESTIMATES FOR STRUCTURES AT NORWAY HOUSE

Structure No.	Square Footage	Estimated Reproduction Cost New per Square Foot	Estimated Reproduction Cost New
1	1,100	$ 6.00	$ 6,600.00
2	178	$ 2.50	$ 445.00
3	302	$ 2.50	$ 755.00
4	346	$ 3.00	$ 1,038.00
5	484	$ 3.00	$ 1,452.00
6	1,030	$16.00	$16,480.00
8	2,293	$15.00	$34,395.00
9	132	$ 2.50	$ 330.00
10	525	$ 2.50	$ 1,312.50
13	349	$ 2.50	$ 872.50
14	1,008	$10.00	$10,080.00
16	1,742	$12.00	$20,904.00
17	1,352	$ 3.00	$ 4,056.00
18	543	$ 6.00	$ 3,258.00
19	720	$ 6.00	$ 4,320.00
20	800	$ 4.00	$ 3,200.00
23	1,705	$ 2.50	$ 4,262.50
24	439	$ 6.00	$ 2,934.00
26	258	$ 2.00	$ 516.00
27	253	$ 6.00	$ 506.00
30	320	$ 2.00	$ 640.00

TABLE 3 (con't)

REPRODUCTION COST NEW ESTIMATES FOR

STRUCTURES AT NORWAY HOUSE

Structure No.	Square Footage	Estimated Reproduction Cost New per Square Foot	Estimated Reproduction Cost New
32	1,960	$ 8.00	$15,680.00
38	864	$16.00	$13,824.00
39	960	$16.00	$15,360.00
41	280	$ 2.00	$ 560.00
42	429	$ 1.50	$ 643.50
45	440	$ 6.00	$ 2,640.00
47	966	$ 6.00	$ 5,796.00
49	672	$ 6.00	$ 4,032.00
50	183	$ 2.50	$ 457.50
54	786	$ 3.00	$ 2,358.00
56	400	$ 3.00	$ 1,200.00
57	738	$ 3.00	$ 2,214.00
59	2,292	$14.00	$32,088.00
60	1,159	$14.00	$16,226.00
61	637	$ 2.50	$ 1,592.50
62	202	$ 2.00	$ 404.00
63	855	$ 2.00	$ 1,710.00
66	434	$ 6.00	$ 2.604.00
67	974	$ 8.00	$ 7,792.00
68	602	$ 6.00	$ 3,612.00
69	615	$ 6.00	$ 1,230.00
71	353	$ 6.00	$ 2,118.00
72	1,065	$ 6.00	$ 6,390.00
74	426	$ 2.50	$ 1,065.00
75	173	$ 2.50	$ 432.50

TABLE 3 (con't)

REPRODUCTION COST NEW ESTIMATES FOR STRUCTURES AT NORWAY HOUSE.

Structure No.	Square Footage	Estimated Reproduction Cost New per Square Foot	Estimated Reproduction Cost New
76	1,146	$ 7.00	$ 8,022.00
77	724	$ 2.50	$ 1,810.00
78	2,143	$ 2.00	$ 4,286.00
79	679	$ 2.50	$ 1,697.50
80	1,174	$ 2.50	$ 2,935.00
82	151	$ 2.50	$ 377.50
83	1,300	$ 2.50	$ 3,250.00
84	1,381	$ 3.00	$ 4,143.00
85	671	$ 2.50	$ 1,677.50
88	575	$ 6.00	$ 3,450.00
89	798	$ 8.00	$ 6,384.00
90	295	$ 6.00	$ 1,770.00
91	500	$ 8.00	$ 4,000.00
92	541	$ 6.00	$ 3,246.00
93	330	$ 6.00	$ 1,980.00
94	641	$ 8.00	$ 5,128.00
95	939	$ 8.00	$ 7,512.00
96	838	$ 8.00	$ 6,704.00
97	302	$ 2.50	$ 755.00
98	737	$ 6.00	$ 4,422.00
99	252	$ 1.00	$ 252.00
101	375	$ 6.00	$ 2,250.00
102	805	$ 7.00	$ 5,635.00
103	343	$ 1.25	$ 428.75
104	288	$ 6.00	$ 1,728.00

TABLE 3 (con't)

REPRODUCTION COST NEW ESTIMATES FOR

STRUCTURES AT NORWAY HOUSE

Structure No.	Square Footage	Estimated Reproduction Cost New per Square Foot	Estimated Reproduction Cost New
105	256	$ 6.00	$ 1,536.00
106	649	$ 6.00	$ 3,894.00
107	736	$ 6.00	$ 4,416.00
108	108	$ 1.25	$ 135.00
109	413	$ 6.00	$ 2,478.00
110	413	$ 6.00	$ 2,478.00
112	543	$ 6.00	$ 3,258.00
113	454	$ 2.50	$ 1,135.00
114	447	$ 1.60	$ 715.20
115	859	$ 2.50	$ 2,147.50
117	618	$ 6.00	$ 3,703.00
118	738	$ 6.00	$ 4,428.00
119	586	$ 8.00	$ 4,688.00
120	945	$ 6.00	$ 5,670.00
121	634	$ 8.00	$ 5,072.00
122	546	$ 1.60	$ 873.60
123	932	$ 8.00	$ 7,456.00
124	288	$ 1.25	$ 360.00
125	463	$ 6.00	$ 2,778.00
126	768	$ 8.00	$ 6,144.00
130	1,164	$ 3.00	$ 3,492. 0
131	576	$ 3.00	$ 1,728.00

TABLE 4

REPRODUCTION COST NEW ESTIMATES FOR STRUCTURES AT CROSS LAKE

Structure No.	Square Footage	Estimated Reproduction Cost New per Square Foot	Estimated Reproduction Cost New
1	1,904	$ 1.00	$ 1,904.00
2	440 1,056	$ 2.00 $ 1.00	$ 880.00 $ 1,056.00
3	625	$ 4.00	$ 2,500.00
5	796	$ 5.00	$ 3,980.00
6	437	$ 1.60	$ 699.20
7	421	$ 2.50	$ 1,052.50
9	540	$ 1.60	$ 864.00
10	138	$ 1.25	$ 172.50
14	192	$ 2.50	$ 480.00
18	167	$ 1.25	$ 208.75
19	145	$ 1.50	$ 217.50
21	763	$ 5.00	$ 3,815.00
22	376	$ 1.60	$ 601.60
23	720	$ 4.50	$ 3,240.00
24	192	$ 2.50	$ 480.00
27	992	$ 5.00	$ 4,960.00
28	385	$ 4.00	$ 1,540.00
29	543	$ 1.25	$ 678.75
30	711	$ 5.00	$ 3,555.00
33	50	$ 1.50	$ 75.00
34	91	$ 1.50	$ 136.50
35	196	$ 1.00	$ 196.00
38	600	$ 5.00	$ 3,000.00
39	80	$ 1.25	$ 100.00
40	426	$ 4.00	$ 1,704.00

TABLE 4 (con't)

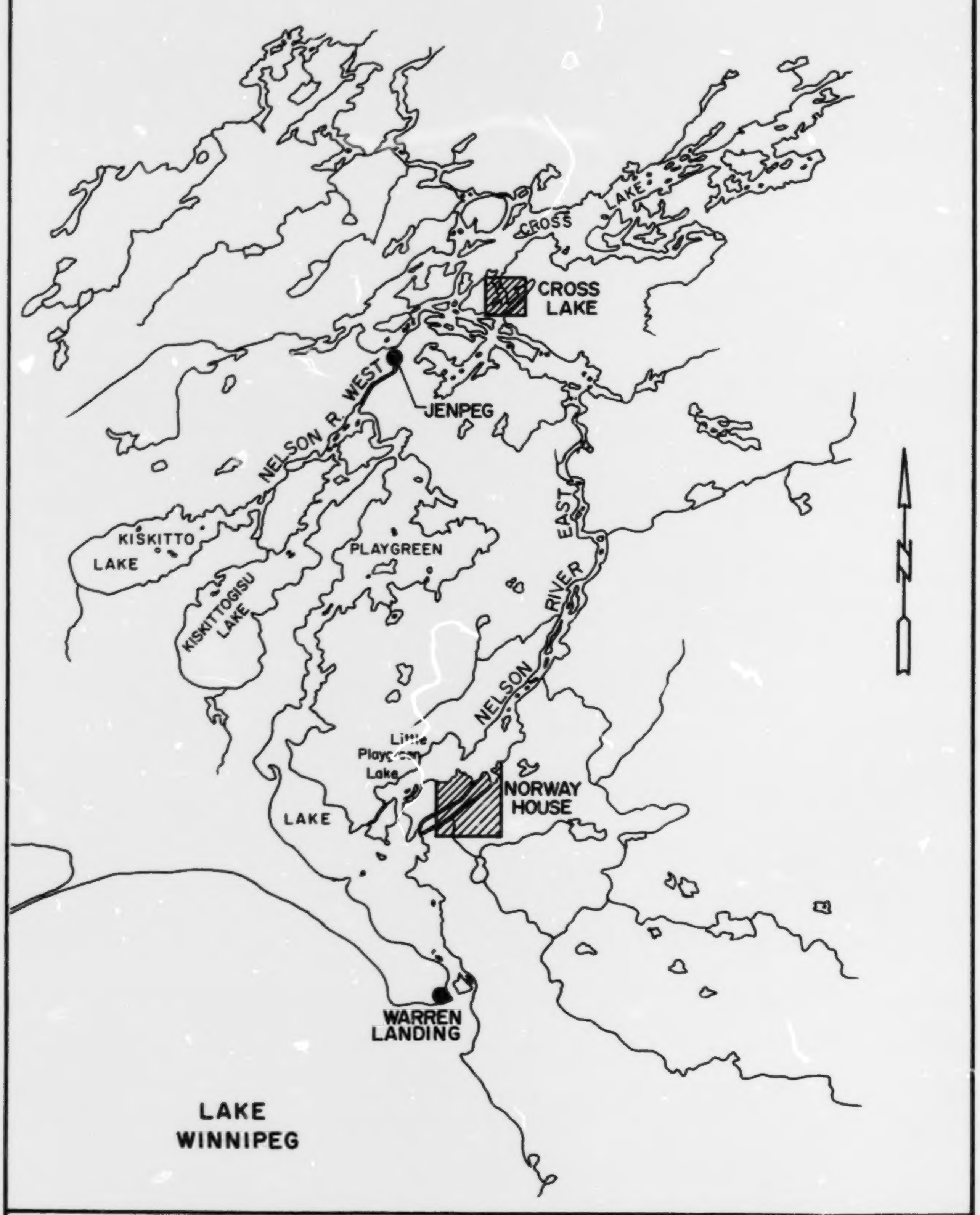
REPRODUCTION COST NEW ESTIMATES FOR STRUCTURES AT CROSS LAKE

Structure No.	Square Footage	Estimated Reproduction Cost New per Square Foot	Estimated Reproduction Cost New
41	236	$ 1.60	$ 377.60
42	992	$ 5.00	$4,960.00
44	707	$ 2.50	$1,767.50
45	584	$ 4.00	$2,336.00
46	360	$ 2.50	$ 900.00
48	520	$ 5.00	$2,600.00
49	610	$ 5.00	$3,050.00
51	796	$ 5.00	$3,980.00
52	473	$ 1.60	$ 756.80
53	747	$ 5.00	$3,735.00
54	112	$ 1.60	$ 179.20

DOCK ASSESSMENT

In the Appraiser's report no allowance was made for docks, but the reproduction "cost new" value of docks and pedestrian bridges in both study areas was estimated by Water Resources personnel. The estimated reproduction "cost new" values per square foot of dock are \$0.65, \$1.30 and \$2.00 depending on the type of construction and materials used. These costs are estimated on the basis of removing the existing deck, raising the existing sub-structure and providing a new deck. These cost estimates will be valid if the modifications can be completed under dry working conditions and provided that the existing sub-structure is in good condition.

Comments made regarding depreciation factors that can be subtracted from the reproduction "cost new" values of buildings to obtain their present physical value can be applied to the docks and pedestrian bridges, as well.


CROSS LAKE
CROSS LAKE
JENPEG
NELSON R. WEST
NELSON RIVER EAST
KISKITTO LAKE
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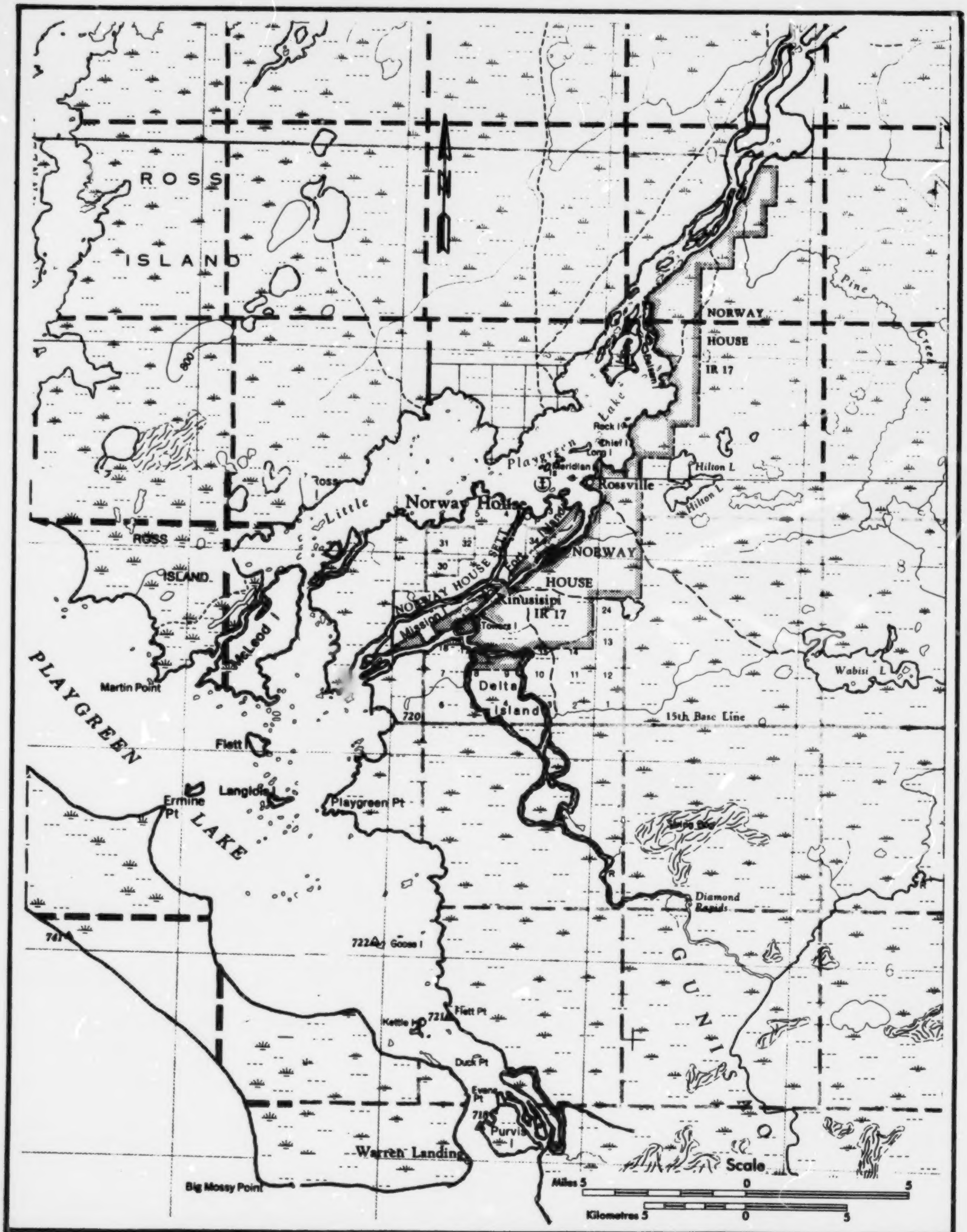
PLAYGREEN LAKE
Little Playgreen Lake
NORWAY HOUSE
WARREN LANDING
LAKE WINNIPEG
N

PROVINCE OF MANITOBA DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT WATER RESOURCES BRANCH					
PREPARED	DRAWN F.R.	SUBMITTED	APPROVED		
	CHECKED	DATE	DATE		
CANADA - MANITOBA LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD LOCATION PLAN					
SCALE N.T.S.	DATE MAR.73	SHEET 1 OF 1	FILE NO.		

FIGURE 1


ROSS ISLAND
ROSS ISLAND
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NORWAY HOUSE IR 17
Pine Creek
Playgreen Lake
Rock I
Chief I
Long I
Meridian
Rossville
Hilton L
Little
Norway House
Ross
NORWAY HOUSE SETT.
Kinusisipi
Mission
Towers I
McLeod I
Martin Point
PLAYGREEN LAKE
Delta Island
15th Base Line
720
Flett I
Langridge I
Ermine Pt
Playgreen Pt
Wabisi L
Diamond Rapids
GUNISAO
722
Goose I
741
721
Kettle I
Flett Pt
Duck Pt
Evans Pt
718
Purvis I
Warren Landing
Big Mossy Point
800
8
7
6
Scale
Miles 5 0 5
Kilometres 5 0 5

PROVINCE OF MANITOBA

DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

WATER RESOURCES BRANCH

CANADA - MANITOBA

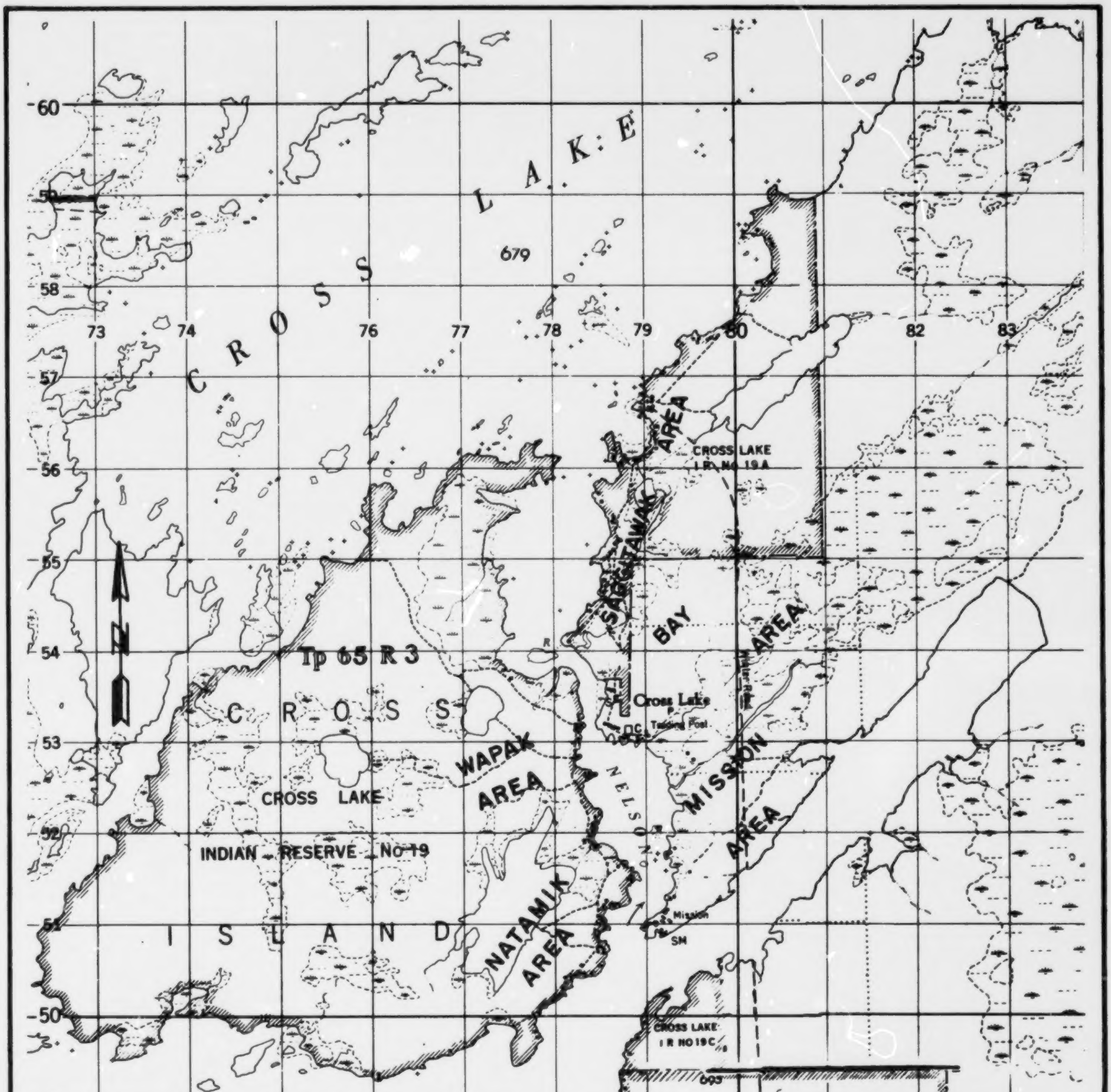
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SITE PLAN

NORWAY HOUSE

PREPARED G.P.	DRAWN F.R. CHECKED	SUBMITTED DATE	APPROVED DATE	SCALE AS SHOWN	DATE MAR./73	SHEET OF	FILE NO.

FIGURE 2


CROSS LAKE
679
Tp 65 R 3
CROSS
CROSS LAKE
INDIAN RESERVE No 19
ISLAND
WAPAK AREA
NATAMIK AREA
SAGGITAWAK AREA
BAY
MISSION AREA
MISSION AREA
CROSS LAKE
I.R. No 19A
Cross Lake
Trading Post
Mission
CROSS LAKE
I R NO 19C
CROSS LAKE
IR No 19B
NELSON
RIVER
73
74
76
77
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Scale
Miles
Kilometres

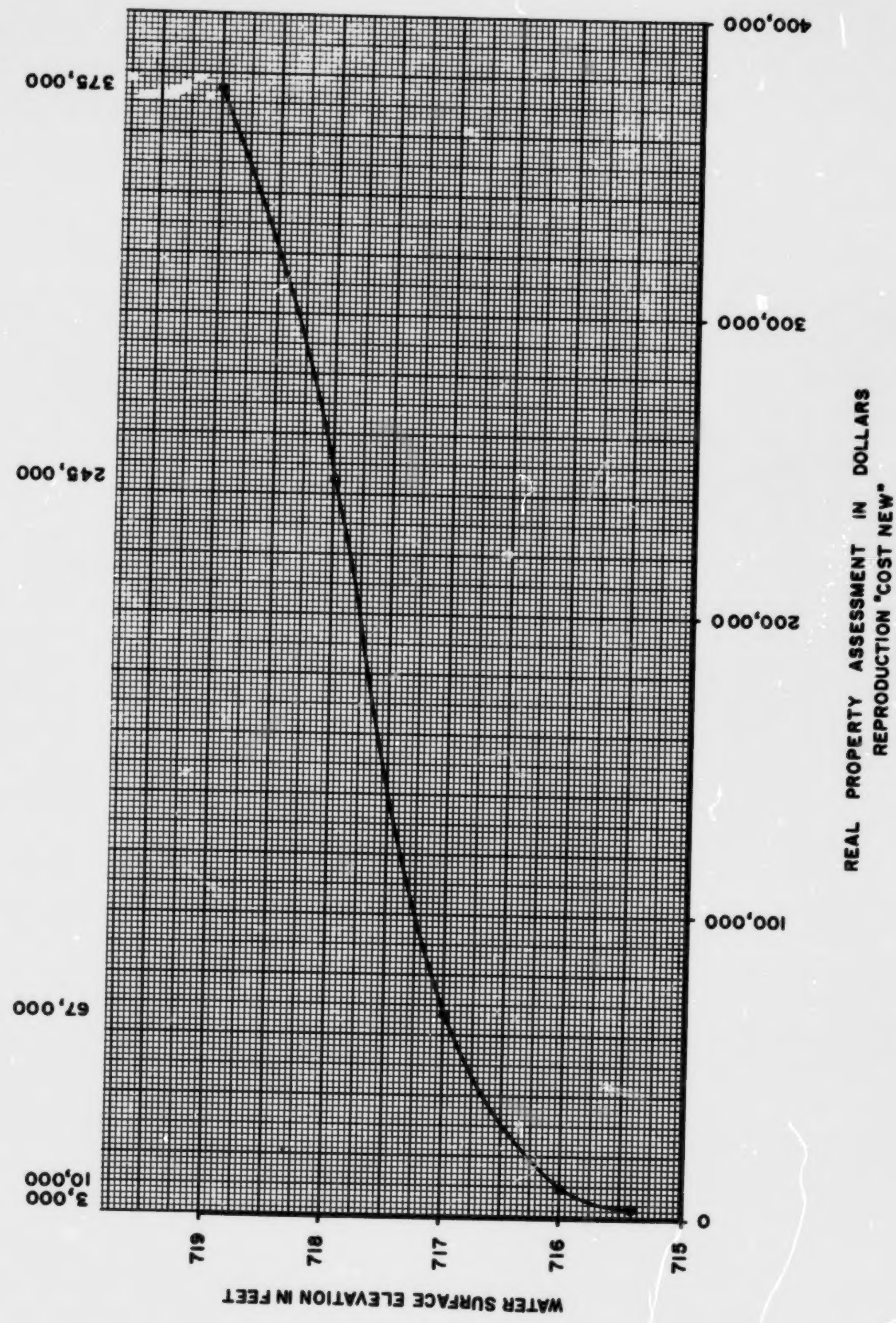
PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SITE PLAN
CROSS LAKE

PREPARED G. P.	DRAWN F.R. CHECKED	SUBMITTED DATE	APPROVED DATE	SCALE AS SHOWN	DATE MAR. 73	SHEET 1 OF 1	FILE NO.

FIGURE 3



PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

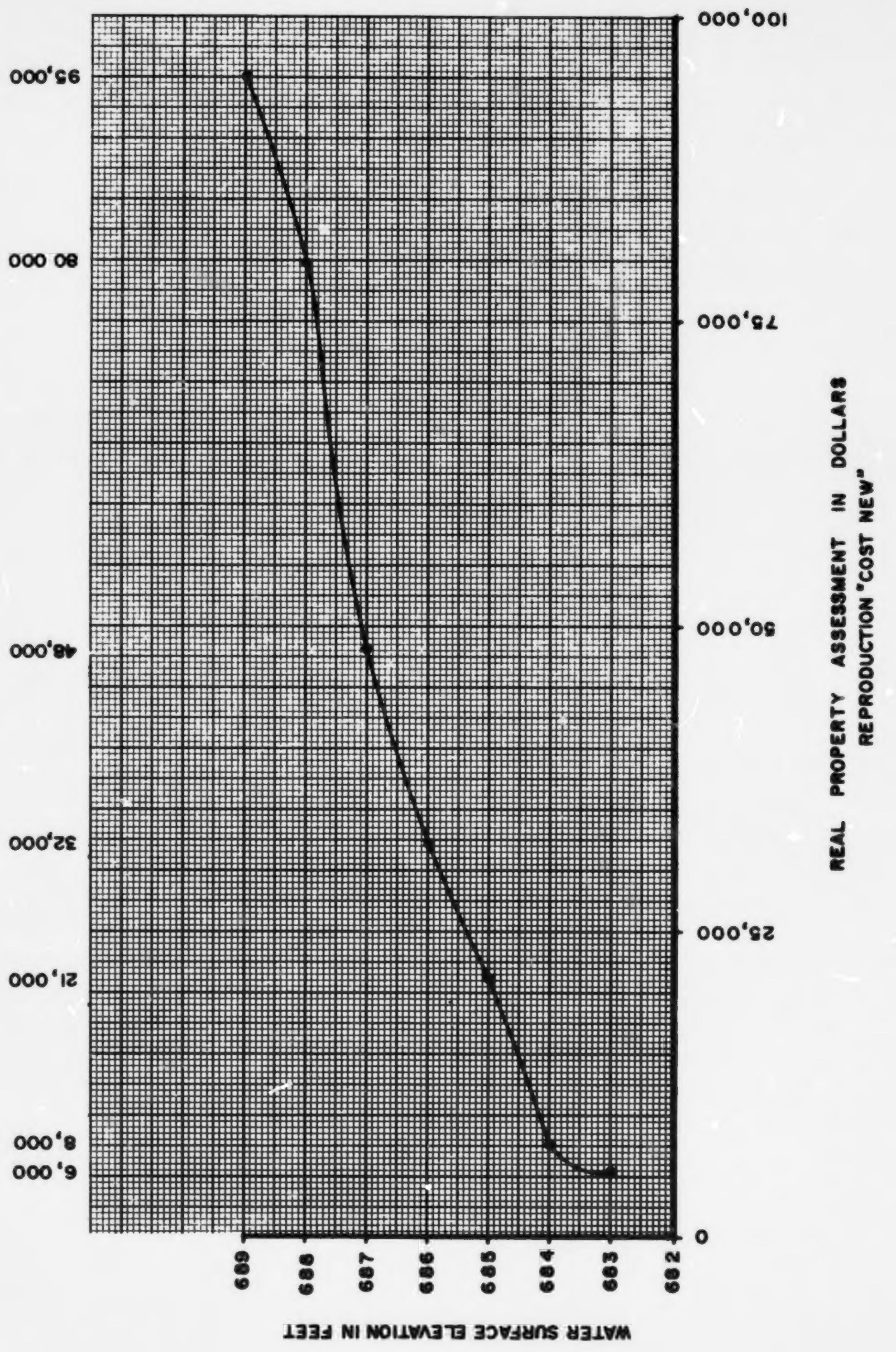
PREPARED	DRAWN	SUBMITTED	APPROVED
G.P	S.S		
	CHECKED	DATE	DATE

CANADA - MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

STAGE - REAL PROPERTY ASSESSMENT CURVE
NORWAY HOUSE AREA

SCALE	DATE	SHEET	FILE NO.
AS SHOWN	MAR. 73	1 OF 1	

FIGURE 4.



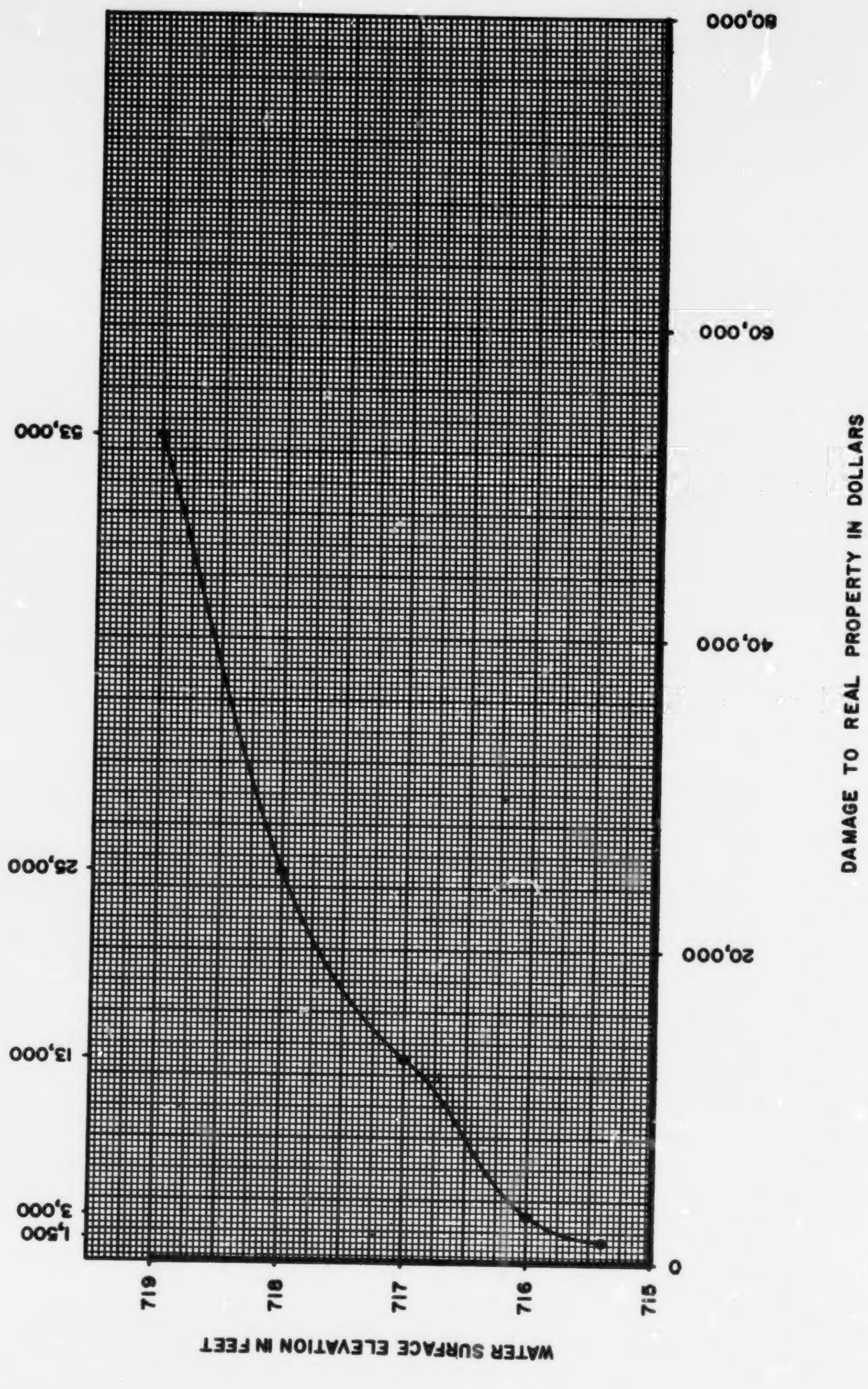
PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA - MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

STAGE-REAL PROPERTY ASSESSMENT CURVE
CROSS LAKE AREA

PREPARED G.P	DRAWN S.S CHECKED	SUBMITTED DATE	APPROVED DATE	SCALE AS SHOWN	DATE MAR. 73	SHEET 1 OF 1	FILE NO.

FIGURE 5.



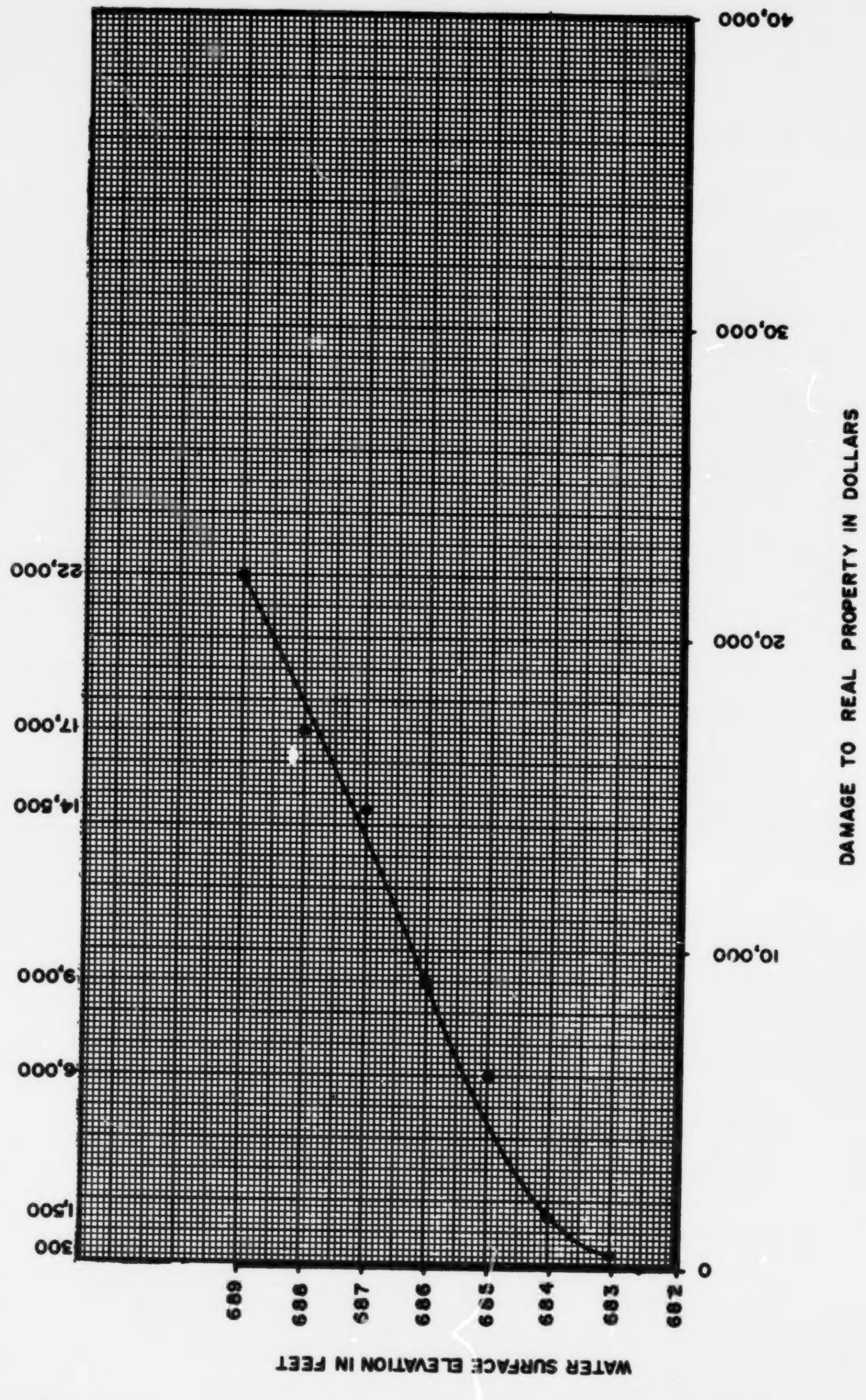
PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

STAGE-DAMAGE CURVE
NORWAY HOUSE AREA

PREPARED G.P
DRAWN F.R.
CHECKED
SUBMITTED
DATE
APPROVED
DATE
SCALE AS SHOWN
DATE JULY 1973
SHEET 1 OF 1
FILE NO.

FIGURE 6



PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

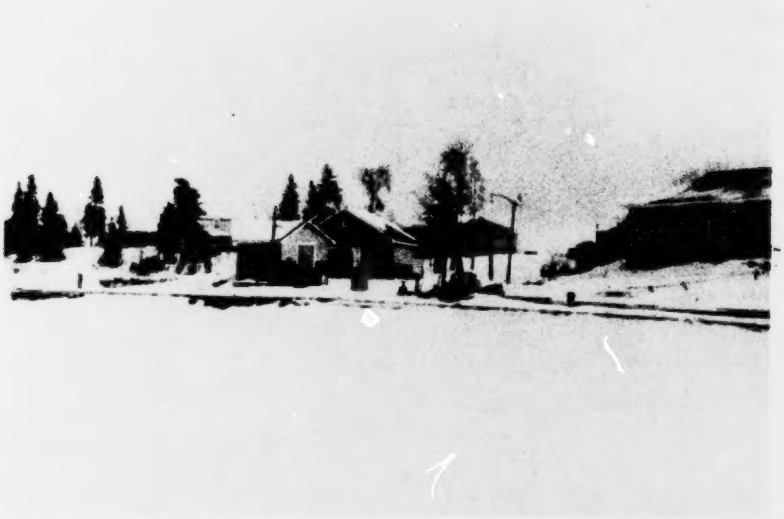
PREPARED	DRAWN	SUBMITTED	APPROVED
G.P	F.R.		
	CHECKED	DATE	DATE

CANADA - MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

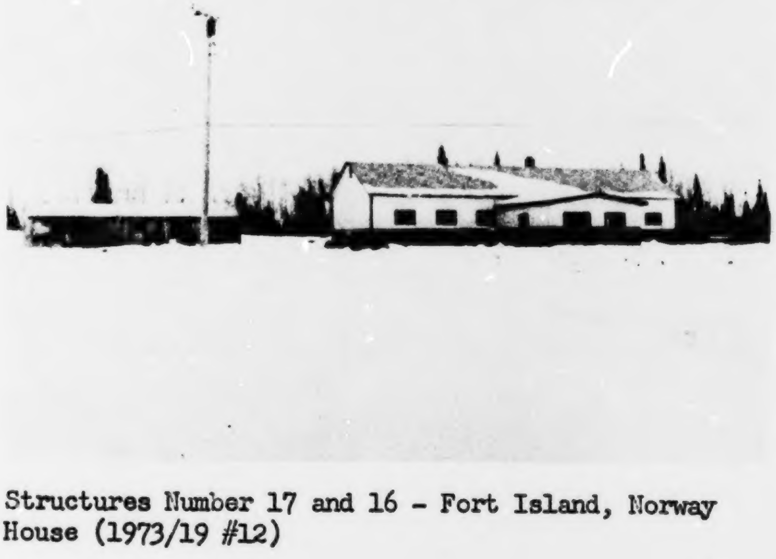
STAGE–DAMAGE CURVE
CROSS LAKE AREA

SCALE	DATE	SHEET	FILE NO
AS SHOWN	JULY 1973	1 OF 1	

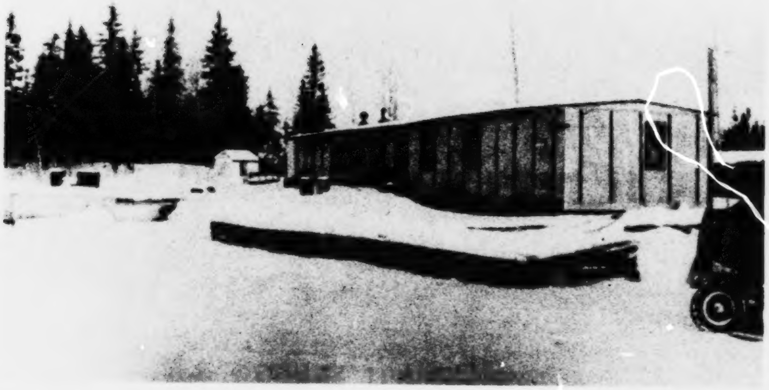
FIGURE 7



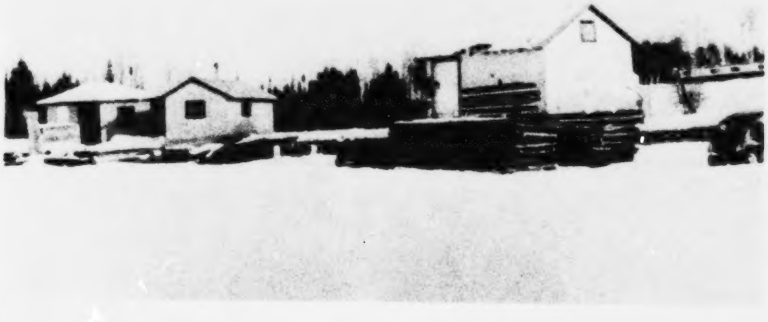
1. Structures Number 9, 10 and 11 - Fort Island, Norway House (1973/19 #10)



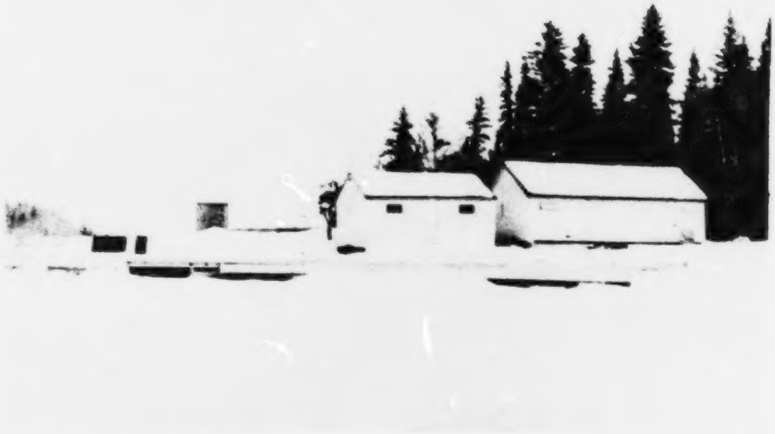
2. Structures Number 17 and 16 - Fort Island, Norway House (1973/19 #12)



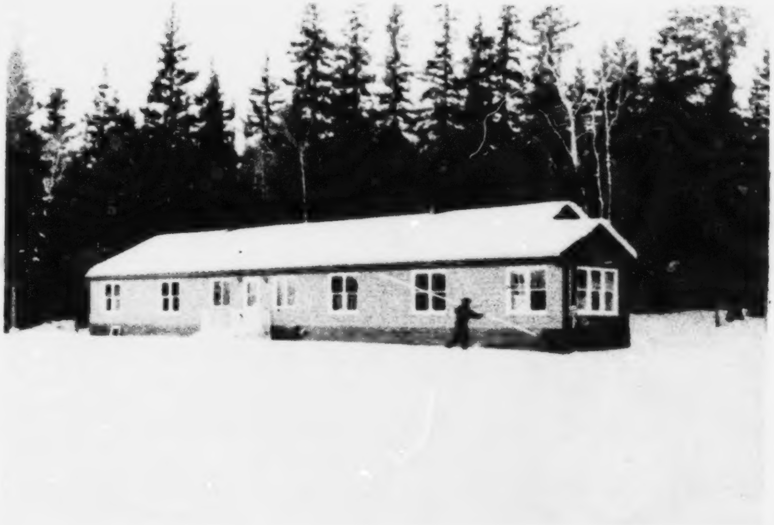
3. Structures Number 22 and 23 - Fort Island, Norway House (1973/19 #14) (dock in foreground excluded)



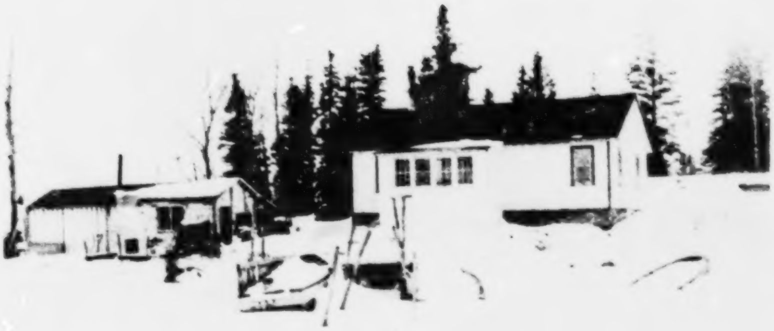
4. Structures Number 25 to 30 - Fort Island, Norway House (1973/19 #15)



5. Structures Number 56, 57 and 58 - Fort Island, Norway House (1973/19 #8)

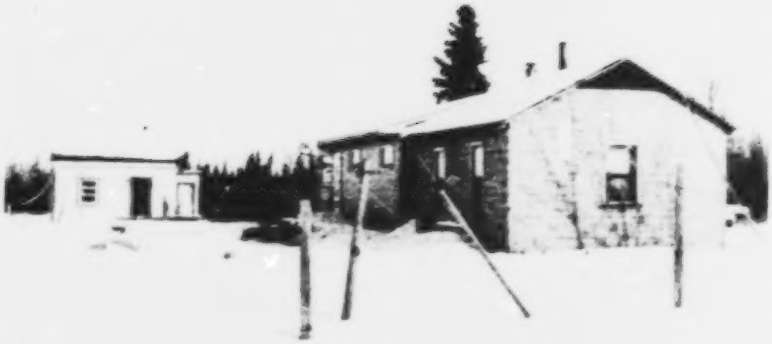


6. Structure Number 59 - Fort Island, Norway House (1973/19 #9)

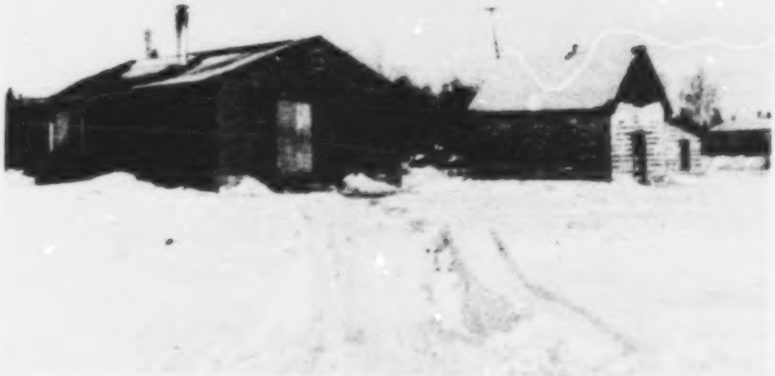


7. Structures Number 61 and 60 - Fort Island, Norway House (1973/22 #2)

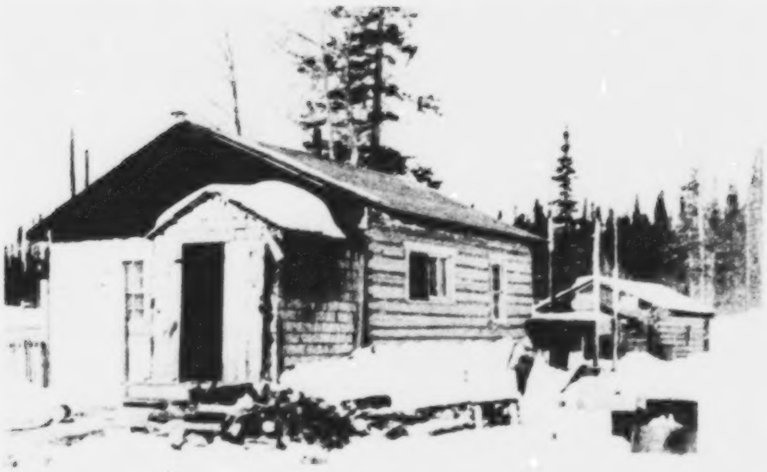
8. Structures Number 66, 67 and 68 - Rossville, Norway House (1973/19 #19) (Small shed in centre excluded - above elevation 720.0 feet)



9. Structures Number 88, 89 and 90 - Rossville, Norway House (1973/21 #6)

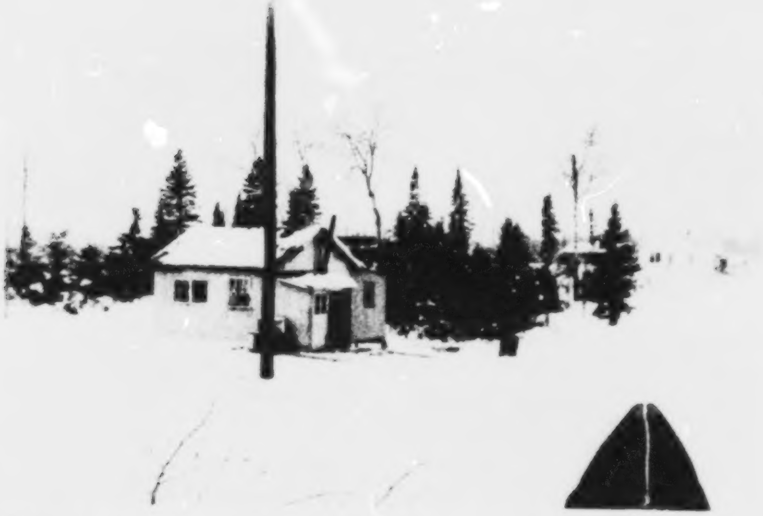


10. Structures Number 121 and 122 - Kinusisipi, Norway House (1973/21 #18)

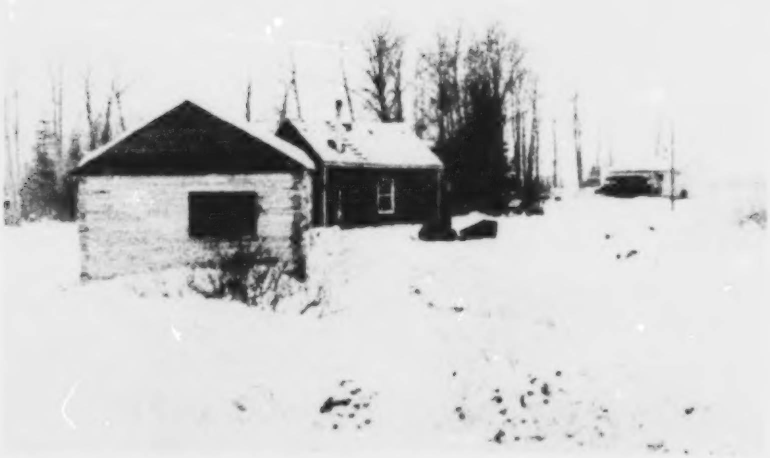


11. Structures Number 9 and 10 - Bay Area, Cross Lake (1973/20 #7)

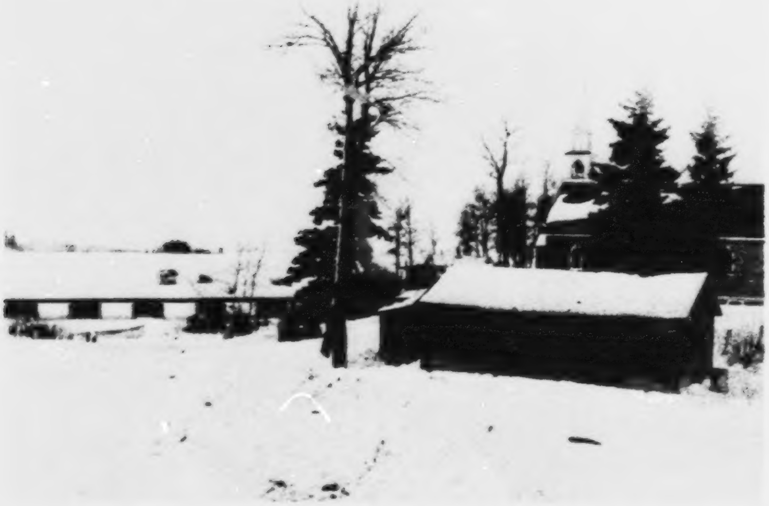
12. Structure Number 20 - Wapak Area, Cross Lake (Foreground) Structures Number 15, 14 and 13 - Bay Area, Cross Lake (far shoreline) (1973/18 #7)



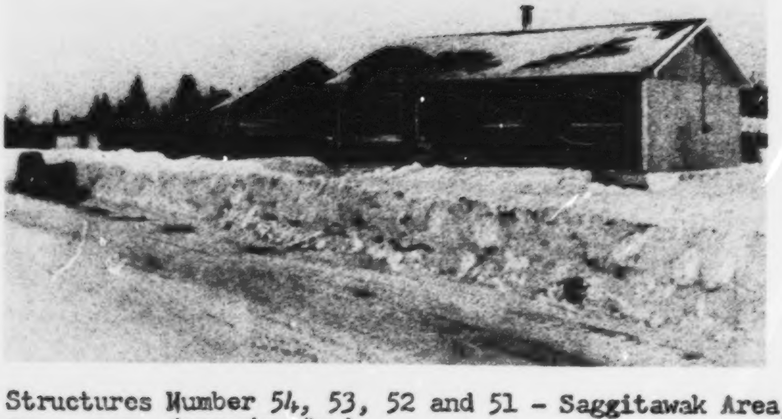
13. Structure Number 28 - Natamik Area, Cross Lake (1973/22 #20)



14. Structures Number 41, 40 and 38 - Saggitawak Area, Cross Lake (1973/20 #9)



15. Structures Number 43, 44, 45 and Church - Saggitawak Area, Cross Lake (1973/20 #11)



16. Structures Number 54, 53, 52 and 51 - Saggitawak Area, Cross Lake (1973/20 #14)

APPENDIX 4 - C

ANTICIPATED EFFECTS OF RAISED LAKE LEVELS ON SHORELINES AT CROSS LAKE, MANITOBA

ANTICIPATED EFFECTS
OF RAISED LAKE LEVELS ON SHORELINES
AT CROSS LAKE, MANITOBA

by

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Manitoba Department of Mines, Resources and Environmental Management
Winnipeg, Manitoba

January, 1974

for

THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SPECIAL NOTE

THE CONCLUSIONS AND RECOMMENDATIONS CONTAINED IN THIS APPENDIX ARE THOSE OF THE AUTHOR(S) AND ARE NOT NECESSARILY THE SAME AS THE CONCLUSIONS AND RECOMMENDATIONS OF THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD AS EXPRESSED IN THE SUMMARY REPORT AND THE TECHNICAL REPORT.

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8	Silty-clay backshore supports abundance of annual and perennial native vegetation.
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10	Profiles, sites 14, 15, 16
11	Profiles, sites 17, 18, 19
12	Profiles, sites 21 and 22

RECOMMENDATIONS

The silty clay causeways [Photograph 1] require raising and rip-rap protection. Their existing levels and construction would not withstand high water levels under natural conditions or under regulated water level conditions.

Lowered summer water levels will require additional private dock step extensions, [Photograph 2]. Raised winter water levels may increase damage to such docks by ice movement.

Cribbed bridge walkways [Photograph 3] are susceptible to heaving caused by increased ice levels. Consideration should be given to preventing possible damage.

ABSTRACT

This report provides information on the classification of the existing shoreline in the Cross Lake Community. Reference is made to common plant species that occur on the backshore, on the shoreline and in the offshore with emphasis on the many bays and marshes. Impact processes resulting from water level regulation are discussed relative to shorelines, vegetation and the effects on community structures.

OBJECTIVES

The objectives are to describe and classify the existing shoreline including offshore and backshore vegetation in the community of Cross Lake, and to predict the effects on these natural conditions by changing the water regime through water level regulation. Other objectives are to determine the effects on the causeways, docks and bridges and present measures to mitigate damage.

TERMS OF REFERENCE

The study was designed to prepare a detailed description and classification of the shoreline including offshore and backshore vegetation in the community of Cross Lake. The study includes a projection of the effect of changes in the water regime on the shoreline including the effect on the vegetation. The effect on the extensive causeway system will also be included and measures to enhance benefits and mitigate damages will be considered.

The study will be similar to the "Physical Impact Study (4), 1973", but greater detail of the area involved will be included.

Related studies on Real Property Assessment, Transportation and Navigation and Physical Impact on the Churchill-Nelson River Systems are not included in this study except for reference purposes.

STUDY AREA

The Cross Lake Community is located on the east channel of the Nelson River as shown in Figure 1. Jenpeg, Wabowden and Norway House are the closest populated areas.

The Cross Lake Transportation Study(1), 1971, quoted the population of Cross Lake Village as being 2000 of which 1800 are treaty Indians and the remainder are Metis, non-treaty Indians and whites. The village is divided into five areas - Natamik, Mission, Wapak, Bay and Saggitawak (Figure 2). The village extends about 6 miles on the east bank of the river channel and about 3 miles on the west bank. Approximately 300 homes and buildings are located within a few hundred feet of the water's edge (Photographs 4 and 5). The river channel, it's numerous bays and shoreline marshes divide and fragment the village. Figure 3 points out the building distribution, backshore contour elevations, shoreline classification, existing causeways, roads and bridges. These are discussed elsewhere in the report.

Water flow data through the Cross Lake Community channel is not available but flows through the Lake vary from 25,000 cfs. to 113,000 cfs. About 85% enters Cross Lake via the west channel (Cross Lake Transportation Study(1), 1971) leaving only 15% of the flow to affect the village shorelines. Cross Lake levels with regulation will change seasonally (Table 1). In general, they will remain within the natural long term range of levels (Figure 4). The range of levels (extreme maximum to extreme minimum) will be marginally increased, by less than one foot.

Table 1

Cross Lake Natural and Regulated Monthly Water Levels

	Natural			Regulated		
	2%	50%	98%	2%	50%	98%
January	675.0	677.2	680.2	676.2	679.2	680.4
February	674.9	676.7	679.4	676.1	678.9	679.9
March	674.8	676.6	678.8	675.2	678.0	679.4
April	674.9	676.7	679.6	674.6	677.0	679.1
May	676.0	678.5	681.6	674.8	676.5	681.4
June	676.8	679.5	683.8	674.5	676.7	684.5
July	676.7	680.0	684.4	674.2	676.8	684.8
August	676.6	679.8	683.8	674.1	676.4	683.8
September	676.5	679.5	683.2	674.7	676.6	680.3
October	676.3	679.5	682.8	674.7	676.8	681.0
November	675.8	678.8	682.4	674.8	677.6	681.1
December	675.2	677.8	682.1	675.8	679.3	680.8

The long term average lake level will be reduced from 678.5 to 677.9 with regulation, a difference of less than one foot. The seasonal distribution of these levels will be changed with generally low levels in summer and higher levels in winter (Figure 4). This is the opposite of the natural state. Both the lowest level of 674.1 feet and the highest level of 684.8 feet will occur in the summer as compared to the natural late winter low of 674.8 and the summer high of 684.4. The range of water levels will be increased by one foot from 9.6 feet to 10.7 feet. Short term fluctuations will be increased. Monthly variation (changes in water levels within one month) in the natural state may be four feet or less in the summer and two feet or less in the winter as compared to a possible six feet and four feet respectively for the regulated system.

The period of open water usually extends from late May to late November (Cross Lake Transportation Study(1), 1971). Until recently summer freight travelled by boat and barge through Warren Landing (Figure 1) to the south end of Wiskey Jack Portage. There was a 5 mile portage by truck to Cross Lake. Winter freight was carried by truck or rail to Wabowden. As a result of an all-weather road to Jenpeg, trucks can deliver freight to water access via Cross Lake to the village. A 20 mile truck road from Jenpeg to Cross Lake Community has been proposed (Outlet Lakes Transportation and Navigation Study(3), 1973).

Air service is supplied by Transair Twin-Otter wheeled aircraft from Winnipeg to Norway House once per day when runway conditions permit. Cross Lake Air Lines float aircraft have scheduled daily flights to Wabowden (Cross Lake Transportation Study(1), 1971).

METHODOLOGY

The Cross Lake Community shoreline was classified using the system described in "Characteristics of Churchill - Nelson Shorelines(4), 1973". The inspection was done by travelling along the shore by boat and making shore profiles at selected study sites as shown in Figure 5. Data was recorded on offshore and backshore vegetation. By reference to information on water level changes by regulation, processes influencing shoreline erosion, offshore and backshore vegetation, and man-made structures were predicted. Factors affecting these processes such as shore materials, wave action, exposure, and seasonal changes in water levels and flows were considered.

Color print photographs and shoreline profiles were used to illustrate study sites.

OBSERVATIONS AND CONCLUSIONS

A. Shorelines

The shoreline within the Cross Lake Community is typically class 13, low bedrock shoreline, as described in "Characteristics of Churchill - Nelson Shorelines(4), 1973". This description is given in Appendix B. The shoreline is extremely irregular (Figure 3) with wide, low and smoothly glaciated bedrock (Photograph 6). The overburden of glacial till soils is essentially made up of fine grained clays and silts as appears in the backshore behind the boulder beach in Photographs 7 and 8.

Class 14 shorelines, bedrock-controlled with overburden beach, occur for relatively short stretches scattered along the predominantly bedrock promontories and may show bedrock outcrops in the backshore (Photographs 9 and 10). The foreshore shows a beach of granular material backed by a low clay bank (Photograph 9).

Class 24, low alluvial shoreline, occurs in one location on the east shore where a small tributary has deposited sediment in a bay (Figure 3). The description is provided in Appendix B.

Class 28, low willowed shoreline, occurs in two locations on the west shore (Figure 3) in shallow embayments. The silty clay overburden supports a dense growth of sedge, Carex spp. and grass, Gramineae (Photograph 11).

B. Vegetation

The dominant forest tree of the area is black spruce, Picea mariana (Photograph 4). White spruce, Picea glauca, occurs commonly on better drained locations. Trembling aspen, Populus tremuloides and balsam poplar, Populus balsamifera, (Photograph 12) are abundant in scattered locations. Less abundant are white birch, Betula papyrifera and some jack pine, Pinus banksiana (Photograph 7).

Alder, Alnus sp. and willow, Salix sp. form a transition zone (commonly 10 to 30 feet) between the forest and foreshore in scattered locations (Photographs 9 and 10). These shrubs form part of the understory in open forest areas as well as along the shorelines. Other commonly occurring shrubs in poorly drained areas are Labrador tea, Ledum groenlandicum, leather leaf, Chamaedaphne calyculata. Bearberry, Arctostaphylos uva-ursi and blueberry, Vaccinium spp. are commonly and widely occuring plants on better drained sites. On the forest floor club moss, Lycopodium spp., and sphagnum moss, Sphagnum spp. are two of the commonost mosses. Reindeer moss, Cladonia rangiferina and Cladonia alpestris are commonly occuring lichens. Additional forest vegetation is listed in the Appendix A.

The backshore adjacent to the shoreline has been changed in may locations by the village inhabitants. Where there is an overburden (usually shallow) of silty clay there is an abundant growth of many species of annual and perennial herbaceous plants (Photograph 8) such as vetch, Vicia spp., goldenrod, Solidage spp., bluebells, Campanula spp., and grasses, Gramineae. In moist locations mint, Mentha spp. and horsetail, Equisetum spp. predominate before even wetter areas are taken by the sedges, Carex spp. (Photograph 10) which may extend out into water depths of about two feet. Bulrush, Scirpus spp. (Photograph 13 and 14) grows in water depths up to six feet. The density of vegetation is sparse in Photograph 13 indicating little overburden on the bedrock in contrast to the dense growth supported by a thick layer of sediment in the protected bay of Photograph 14.

Intermingling with the bulrush and extending into deeper water are many areas of offshore vegetation as located on Figure 3. This vegetation consists of many species such as white water buttercup, Ranunculus subrigidus (up to 5 feet of water), several species of pondweed, Potamogeton spp. (see Appendix A) (up to 6 feet of water), smartweed, Polygonum spp. (6 to 8 feet of water), coontail, Ceratophyllum demersum, a submerged species in up to 30 feet of water and bladder wort, Utricularia vulgaris often floating in vegetative beds in protected bays.

C. Erosion

Erosion is a major factor of impact processes and is affected by shore materials, shore incline, wave action (exposure), water levels and flows, and ice movements. Shore materials were described under the subheading "Shorelines". Shore inclines were determined at strategic sites throughout the Cross Lake Community as shown in Figure 5. Profiles corresponding to the study site numbers are graphically displayed in Figures 6 to 12. These profiles were made September 2 and 3, 1973, when water levels were 678.09 and 677.94 respectively, (personal communication with Lester Leung, Water Resources). For purposes of standardizing the water level (for the two days) as reproduced on the graphs, the water level, 678.0 feet was used. The profiles show that most of the shoreline is low bedrock controlled with shallow overburden. Water levels and flows (discussed elsewhere in this report), although changed seasonally, are not of sufficient magnitude to cause significant soil erosion from low bedrock shorelines with a thin overburden.

Wave action will cause little shoreline erosion because of the short water fetch (exposure) in the east channel of the Nelson River through Cross Lake Village (Figure 2) and because the shoreline is bedrock controlled. In most areas the water fetch is less than one-half mile. However, where causeways are built of silty clay material (Photograph 1) wave action will have an extreme eroding effect. Under natural water level conditions the present causeways would be exposed to damage by wave action during occasional high water levels. This would also occur at regulated water levels on occasion unless the causeways are raised and protected by rip-rapping.

No damage is anticipated to dwellings (Photograph 4) or major construction buildings (Photograph 5 and 15) because they are located above expected high water levels.

No damage or navigation problems will occur at the suspension bridge walkway (Photograph 16).

D. Ice

Docks (Photograph 2) and cribbed bridge walkways (Photograph 3) will be damaged by the pressure of ice as water levels are increased during November and December. Rises during one month of between 2 and 4 feet will occur once in three or four years for either month. A rise of more than one foot will occur once in two years on the average during either or both months.

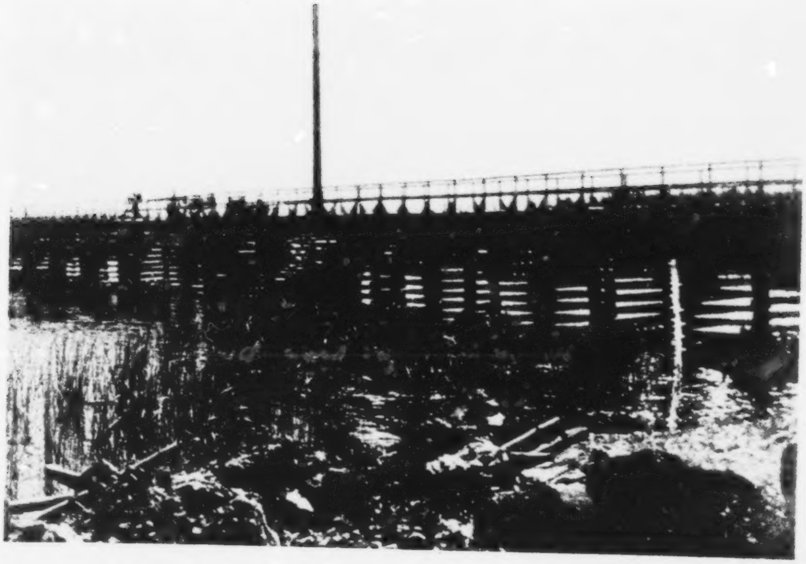
Fluctuating summer water levels under regulation will necessitate further dock-step extensions (one dock extension shown in Photograph 2). This will increase ice damage during the winter unless preventative methods are introduced.

REFERENCES

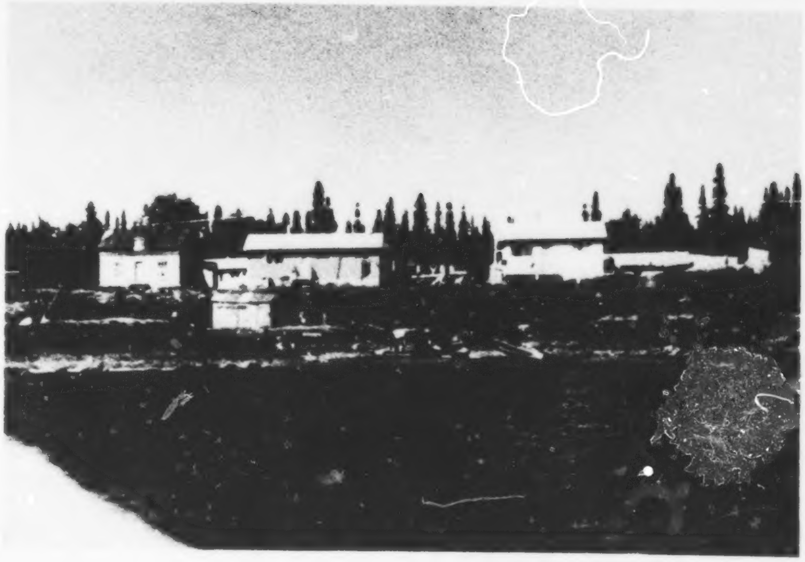
1. Canada Department of Indian Affairs and Northern Development, "Cross Lake Transportation Study", 1971.
2. Canada-Manitoba Lake Winnipeg, Churchill and Nelson Rivers Study Board, "Real Property Assessment Outlet Lakes Area", March, 1973.
3. Canada-Manitoba Lake Winnipeg, Churchill and Nelson Rivers Study Board, "Outlet Lakes Transportation and Navigation Study", January, 1973.
4. University of Manitoba, Department of Civil Engineering, Physical Impact Study, Interim Report, "Characteristics of Churchill-Nelson Shorelines", 1973.

PHOTOGRAPH 1 - Graded Silty Clay Causeway, Cross Lake Village

PHOTOGRAPH 2 - Privately Owned Boat Dock, Cross Lake Village



PHOTOGRAPH 3 - Cribbed Bridge Walkway, Cross Lake Village



PHOTOGRAPH 4 - Dwellings, Cross Lake Community

PHOTOGRAPH 5 - Lumber Mill, Cross Lake Community

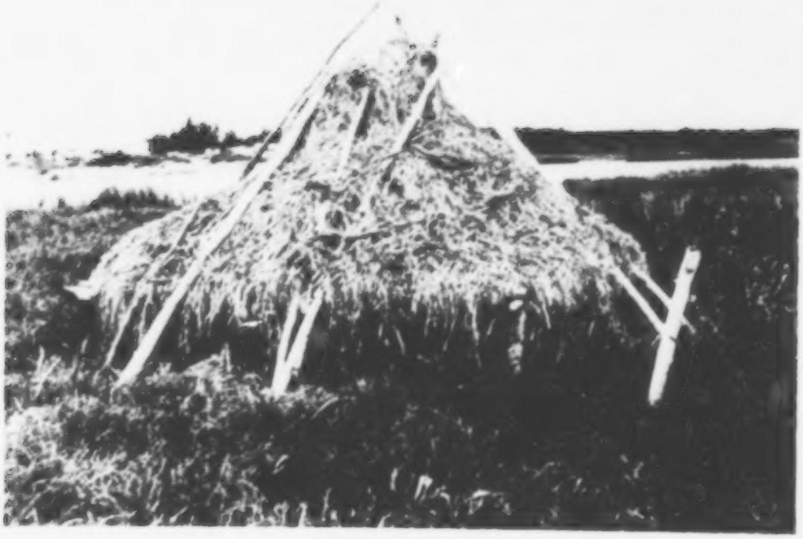
PHOTOGRAPH 6 - Precambrian Shield Bedrock, Cross Lake Village

PHOTOGRAPH 7 - Scattered Glacial Till Boulders and Silty Clay Bank, Cross Lake Village

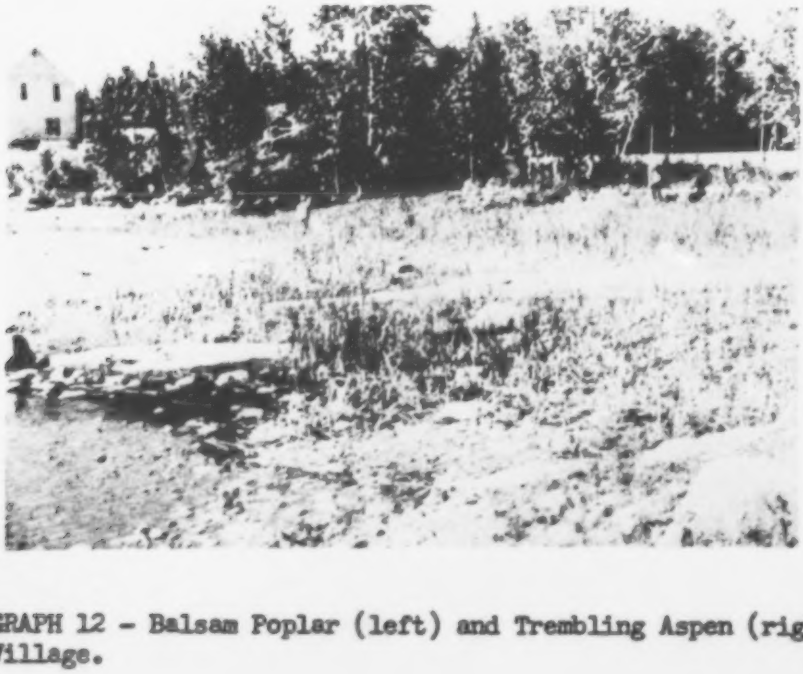
PHOTOGRAPH 8 - Silty-clay Backshore Supports Abundance of Annual and Perennial Native Vegetation

PHOTOGRAPH 9 - Bedrock Outcrop in Background Behind an Alnus sp. and Salix sp. Zone, Fronted by Scirpus sp. and Carex sp. Extending to a Granular Shoreline, Cross Lake Village

PHOTOGRAPH 10 - Forest (mainly Picea mariana) Fronted by Salix sp. and Alnus sp. Fringe Behind a Carex sp. Zone. Bedrock Outcrop at Lower Left.



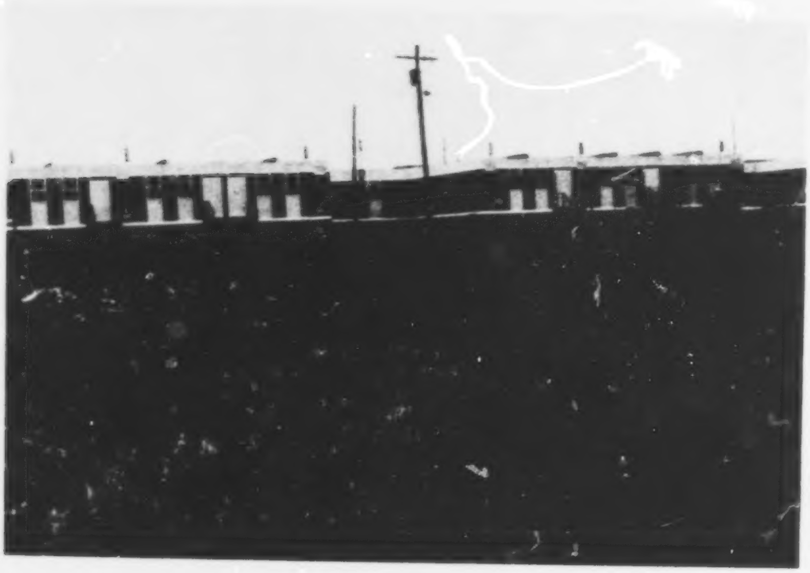
PHOTOGRAPH 11 - Marsh Bay. Silty Clay Supports Dense Vegetation. The Haystack is Raised to Prevent Damage from Periodic Flooding. A Willow and Alder Zone Appears at the Upper Right Before the Forest, Cross Lake Village.



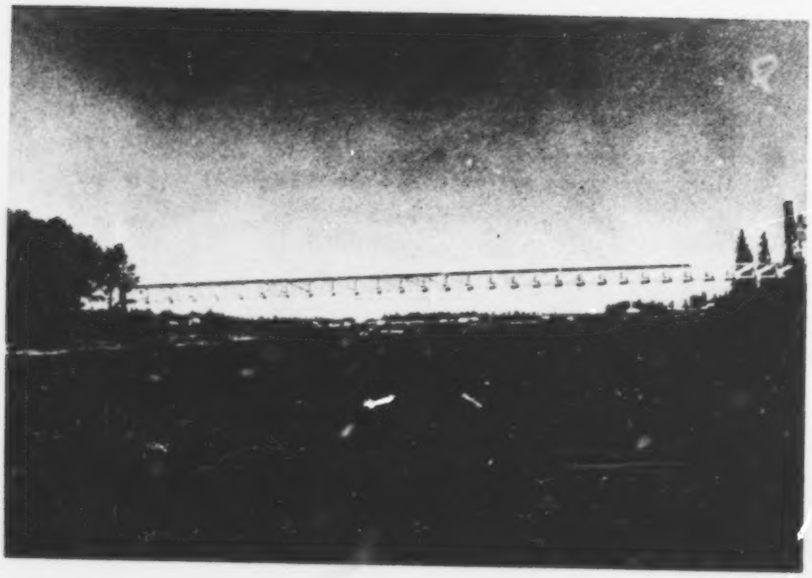
PHOTOGRAPH 12 - Balsam Poplar (left) and Trembling Aspen (right), Cross Lake Village.

PHOTOGRAPH 13 - Bulrush, Scirpus sp., Sparse Growth Indicating Little Overburden on Bedrock, Cross Lake Village.

PHOTOGRAPH 14 - Bulrush, Scirpus sp., Dense Growth Supported by Thick Layers of Sediment in a Protected Bay, Cross Lake Village.



PHOTOGRAPH 15 - High School, Cross Lake Community



PHOTOGRAPH 16 - Suspension Bridge Walkway, East Channel Nelson River, Cross Lake Community

APPENDIX A

VEGETATION

PARTIAL LIST OF PLANTS CROSS LAKE COMMUNITY

LATIN NAME	COMMON NAME
Abies balsamea	balsam fir
Achillea sp.	yarrow
Alnus sp.	alder
Andromeda glaucophylla	bog-rosemary
Aralia nudicaulis	wild sarsaparilla
Arctostaphylos uva-ursi	bearberry
Aster sp.	aster
Astragalus sp.	milk-vetch
Betula glandulosum	drawf birch
Betula papyrifera	paper birch
Campanula sp.	bellflower
Carex sp.	sedge
Chamaedaphne calyculata	leatherleaf
Ceratophyllum demersum	coontail
Cladonia rangiferina	reindeer moss
Cornus canadensis	bunchberry
Cornus stolonifera	red-osier dogwood
Epilobium angustifolium	fireweed
Equisetum sp.	horsetail
Gramineae	grass
Juniperus Communis	juniper
Kalmia polifolia	bog-laurel
Larix laricina	tamarack
Ledum groenlandicum	Labrador tea
Lemna sp.	duckweed
Linnaea borealis	twinflower
Lycopodium sp.	club moss
Maianthemum canadense	wild lily-of-the-valley
Myrica gale	sweet gale
Petasites palmatus	coltsfoot
Picea glauca	white spruce
Picea mariana	black spruce
Pinus banksiana	jackpine
Poa sp.	meadow grass
Populus balsamifera	black poplar
Populus tremuloides	trembling aspen
Polygonum spp.	smartweed
Potamogeton richardsonii	clasping leaf pondweed
Potamogeton vaginatus	sheathed pondweed
Potentilla tridentata	three-toothed cinquefoil

LATIN NAME	COMMON NAME
Ribes sp.	currant
Rubus spp.	raspberry
Salix sp.	willow
Scirpus sp.	bulrush
Senecio sp.	groundsel
Solidago sp.	goldenrod
Sphagnum sp.	sphagnum moss
Utricularia vulgaris	bladder wort
Vaccinium spp.	blueberry
Vicia americana	vetch

APPENDIX B

SHORELINE CLASSIFICATION SYSTEM

"Characteristics of Churchill-Nelson Shorelines(4), 1973"

CLASSIFICATION 13: LOW BEDROCK SHORELINE

Shoreline Types 13, 14 and 15 are areally associated and physically similar, but with significant differences at the land-water interface. Types 14 and 15 commonly occur as protected shorelines scattered among protruding headlands of Type 13.

An extremely irregular shoreline is a characteristic of areas predominated by Type 13. It is widely distributed along river banks and lakeshores in the Canadian Shield. The bedrock is usually granite to diorite, or gneissic granite or granodiorite. The outcrops are generally wide, low and smoothly glaciated, and the average water-washed zone is between 10 and 20 feet wide. The overburden thinly covering most of the backshore is lacustrine deposits of glacial till, and colluvium. Drainage is generally good throughout this profile; permafrost may be found where organic layers insulate it.

Vegetation on the exposed shoreline is sparse but may include Gramineae, Solidago spp., Campanula sp., Epilobium angustifolium, Vicia spp., and Aster spp.

Immediately behind the exposed rock is a narrow zone of scrub including Salix sp., Alnus sp., and Juniperus communis.

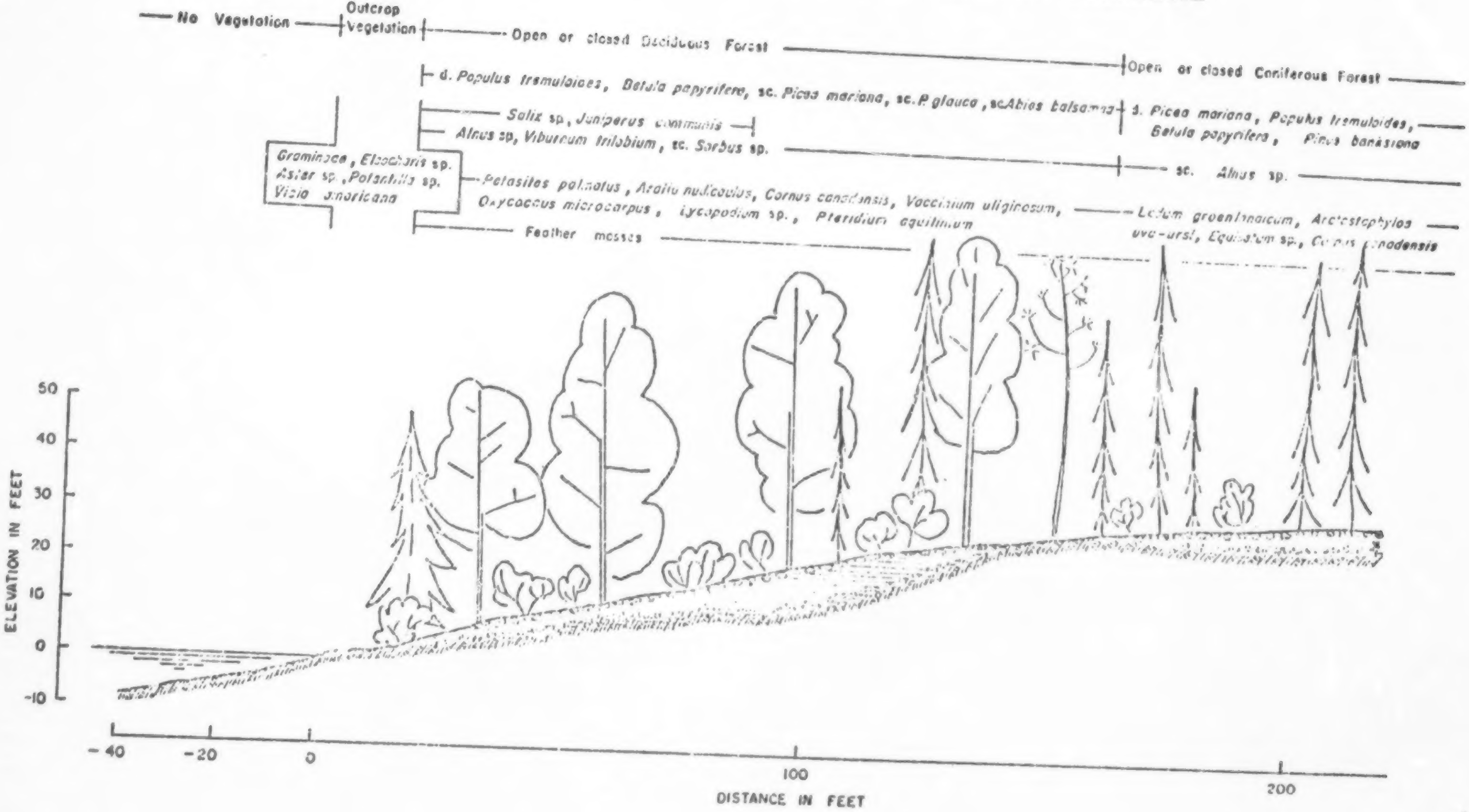
This grades into the third zone which may include any of Picea mariana, Picea glauca, Populus tremuloides, Populus balsamifera, Betula papyrifera and occasionally Pinus banksiana, as tree types. An understory of Salix sp. and Alnus sp. continues. Ground cover includes Ledum groenlandicum, Arctostaphylous uva-ursi, Aralia nudicaulis, Cornus canadensis, Viburnum trilobum, Pteridium sp., Linnaea borealis and Sphagnum sp., or feather mosses. This all grades back to the typical closed coniferous forest of the uplands.

Low bedrock shorelines are found throughout a large portion of the study area along the Rat-Burntwood, Nelson and Churchill Rivers.

FIGURE ;

CLASSIFICATION 13

LOW BEDROCK SHORELINE


No Vegetation
Outcrop Vegetation
Open or closed Deciduous Forest
Open or closed Coniferous Forest
d. Populus tremuloides, Betula papyrifera, sc. Picea mariana, sc. P. glauca, sc. Abies balsamea
d. Picea mariana, Populus tremuloides, Betula papyrifera, Pinus banksiana
Salix sp., Juniperus communis
Alnus sp., Viburnum trilobium, sc. Sorbus sp.
sc. Alnus sp.
Gramineae, Eleocharis sp. Aster sp., Potentilla sp. Vicia americana
Petasites palmatus, Aralia nudicaulis, Cornus canadensis, Vaccinium uliginosum, Oxycoccus microcarpus, Lycopodium sp., Pteridium aquilinum
Ledum groenlandicum, Arctostaphylos uva-ursi, Equisetum sp., Cornus canadensis
Feather mosses
ELEVATION IN FEET
50
40
30
20
10
0
-10
-40
-20
0
100
200
DISTANCE IN FEET

CLASSIFICATION 14: BEDROCK-CONTROLLED SHORELINE WITH OVERBURDEN BEACH

Type 14 shorelines are similar to Type 13 but exhibit no bedrock outcrops except on occasion in the backshore. Overburden beaches from along relatively regular stretches of shoreline connecting bedrock promontories.

The foreshore is normally a beach of granular material or clay backed by a low clay or till bank. The overburden thinly covers the bedrock in the backshore; the slope is moderate.

Occasionally the beaches exhibit scattered scrub of Populus tremuloides, Populus balsamifera, Salix sp., Alnus sp., with Gramineae or Carex sp.

As with the previous type, backshore vegetation consists of various combinations of Picea mariana, Picea glauca, Populus tremuloides, Populus balsamifera and Betula papyrifera. Alnus sp., usually makes up the understory and the ground cover includes Ledum groenlandicum, Arctostaphylos uva-ursi, Cornus canadensis, Viburnum trilobum, Cassandra sp., Kalmia polifolia and Sphagnum sp.

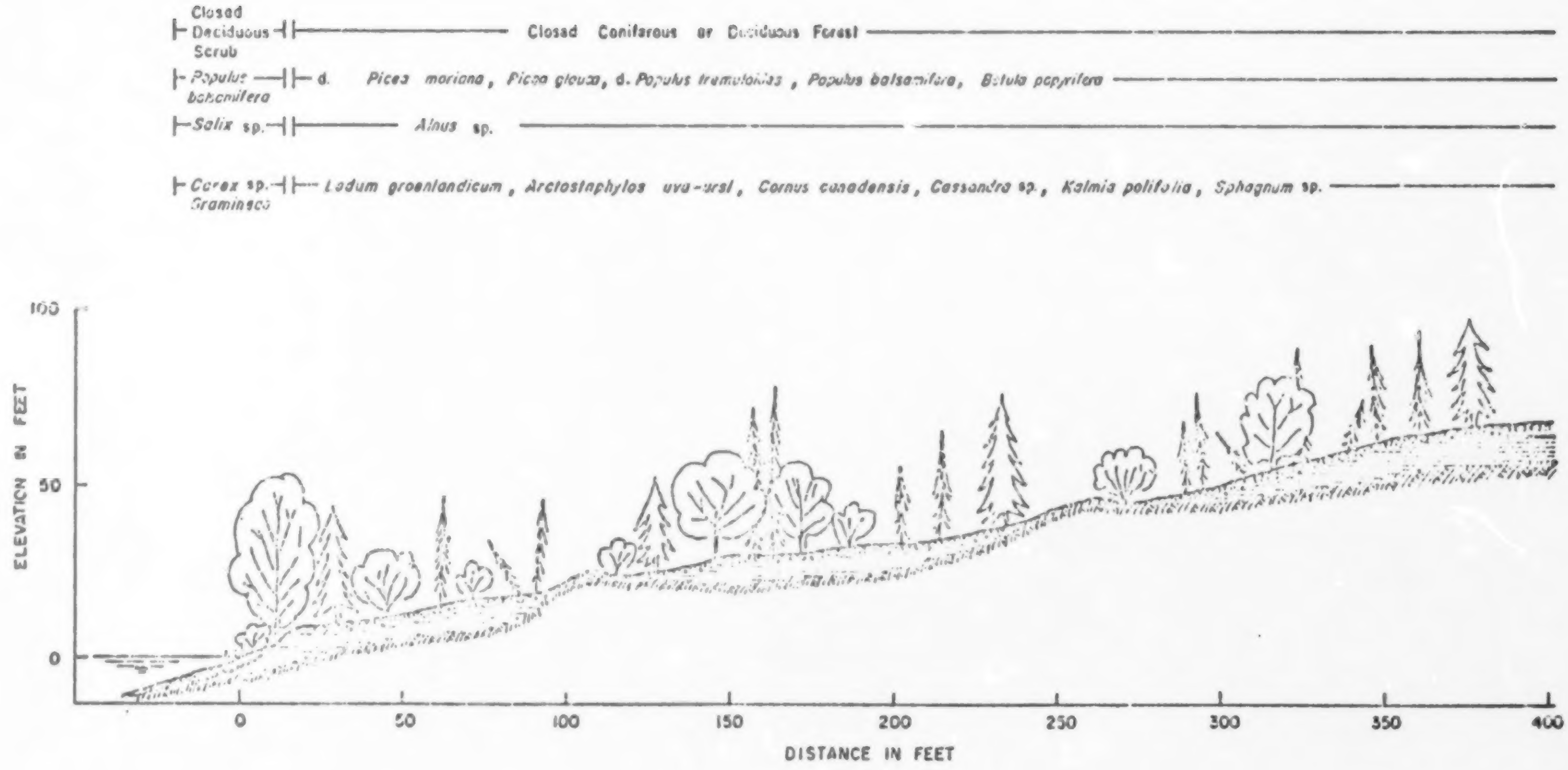
This shoreline type is entensive along all of the Rat-Burntwood, Churchill and Nelson systems.

FIGURE ii

CLASSIFICATION 14

BEDROCK – CONTROLLED SHORELINE

WITH OVERBURDEN BEACH


Closed Deciduous Scrub
Closed Coniferous or Deciduous Forest
Populus balsamifera
d. Picea mariana, Picea glauca, d. Populus tremuloides, Populus balsamifera, Betula papyrifera
Salix sp.
Alnus sp.
Carex sp. Gramineae
Ledum groenlandicum, Arctostaphylos uva-ursi, Cornus canadensis, Cassandra sp., Kalmia polifolia, Sphagnum sp.
ELEVATION IN FEET
100
50
0
0
50
100
150
200
250
300
350
400
DISTANCE IN FEET

CLASSIFICATION 24: LOW ALLUVIAL SHORELINE

The low cross-section is typical of two types of situations. One is in embayments near the mouth of very small tributaries that deposit sediments in the bays, and the other is in depositional areas along riverbanks. In either case, the deposits, which are normally granular, are reworked by current and waves to give a beachlike shoreline. The mild slope extends for several feet offshore and the overgrown beach may extend 100 feet inshore. The backshore is low, rises slowly and is a victim of poor drainage. Occasional potholes are found in this area. The beach material is usually granular but can be fine-grained. The sand grades, over a distance of 200-300 feet, to finer materials frequently containing permafrost.

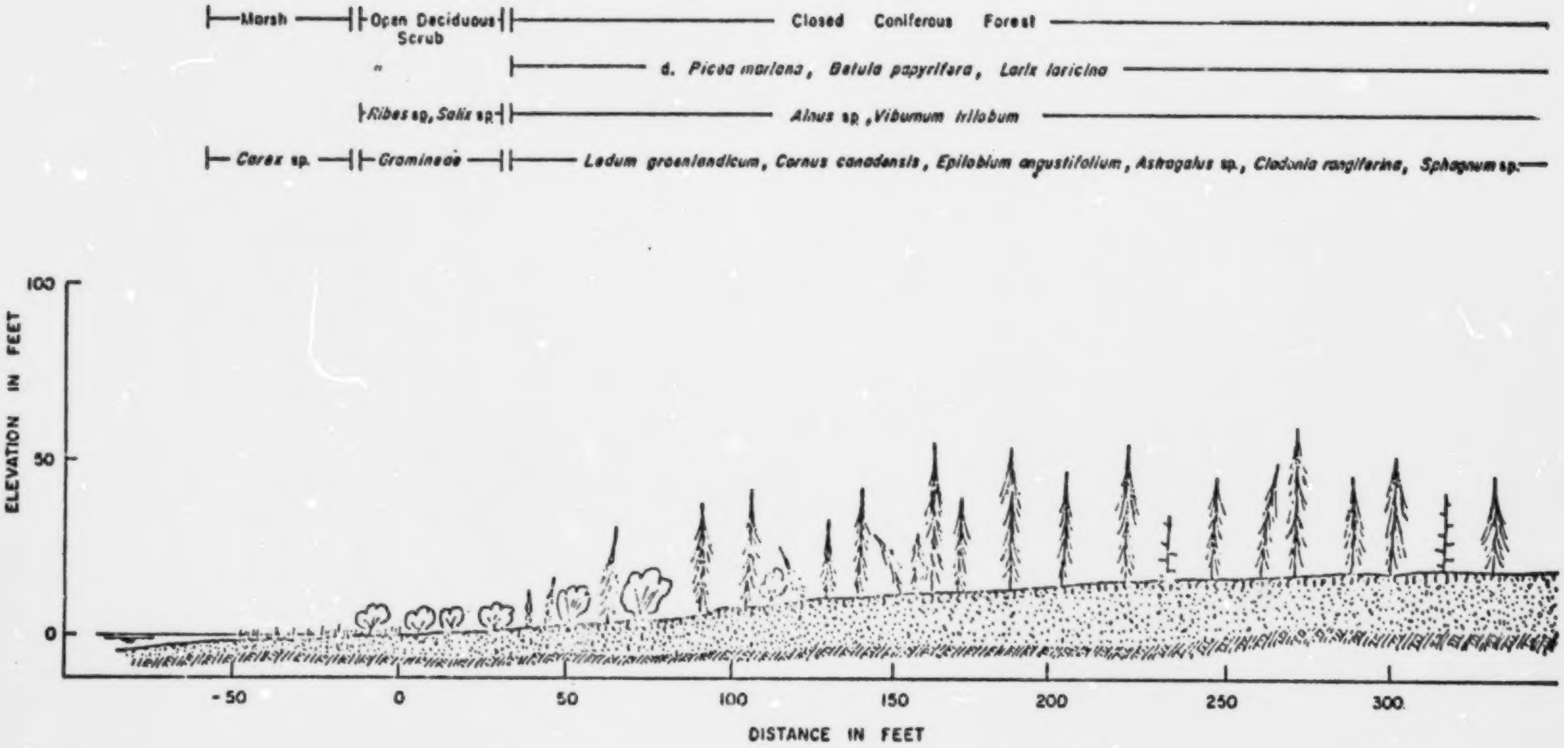
Offshore vegetation is mainly *Carex* sp., with an infringement of *Salix* sp. The shoreline itself is an open deciduous scrub consisting of *Salix* sp., *Ribes* sp., with *Gramineae* ground cover. Beginning about 50 feet from shore is a closed coniferous forest with the dominant species being *Picea mariana*. Scattered *Betula papyrifera* and *Larix laricina* add to the tree community. The understory in the backshore includes *Alnus* sp. and *Viburnum trilobum*. Ground cover consists of *Ledum groenlandicum*, *Cornus canadensis*, *Epilobium angustifolium*, *Astragalus* sp., *Cladonia rangiferina* and *Sphagnum* sp.

Shorelines of Type 24 are not widespread but tend to be very productive biologically.

FIGURE iii

CLASSIFICATION 24

LOW ALLUVIAL SHORELINE


Marsh
Open Deciduous Scrub
Closed Coniferous Forest
"
d. Picea mariana, Betula papyrifera, Larix laricina
Ribes sp., Salix sp.
Alnus sp., Viburnum trilobum
Carex sp.
Gramineae
Ledum groenlandicum, Cornus canadensis, Epilobium angustifolium, Astragalus sp., Cladonia rangiferina, Sphagnum sp.
ELEVATION IN FEET
100
50
0
-50
0
50
100
150
200
250
300
DISTANCE IN FEET

CLASSIFICATION 28: LOW WILLOWED SHORELINE

Shorelines with a broad, low willow and alder zone are typically regular and concave and occur around shallow embayments. They are most commonly associated with bedrock controlled shorelines of Type 13, 14 and 15 and sometimes with treed muskeg shorelines of Type 26.

Relief is low; the profile is horizontal and less than 5 feet above water level as far as 50 to 500 feet from the water's edge, where begins a gentle rise to the uplands.

The low zone is over clay, silty clay, greater than ten feet deep, underlain by bedrock. The bedrock rises gently and may outcrop in the backshore; it is commonly exposed on adjacent headlands. Where such shorelines are associated with treed muskeg, depth to bedrock is normally greater. The beach area is of exposed clay, but back of it the low zone may be overlain by up to 4 feet of sphagnum or forest peat; more commonly the organic layer is less than a foot thick. Permafrost occurs where the organic layer and drainage characteristics permit.

Typically an offshore zone of marsh vegetation is present; the nature of the marsh community varies significantly over the area mapped. (Where a marsh occurs, the shoreline is mapped as 28m.) It may consist of zones of Gramineae and Carex spp., commonly with Lemna sp., immediately adjacent to and onto the beach or of offshore stands of Scirpus sp. Width of the zones is dependent on offshore slope, Gramineae typically growing on shore and in depths of less than 6 inches of water, Carex spp., growing from the water's edge into water up to 2 feet in depth, and Scirpus sp., normally in 2 to 4 feet of water. Large marshes may extend beyond 1000 feet from shore, with complete zonation of vegetation as described above, and with Potamogeton sp. scattered throughout and beyond.

The characteristic zone of type 28 is the broad belt of closed deciduous scrub stretching 50 to 500 feet back from the water's edge to the first slopes. It is a zone of poor drainage and commonly of standing water in small pools. Dominant species are Alnus sp., and Salix sp. shrubs, with very scattered Betula papyrifera and Picea mariana shrubs and trees increasing in abundance with increasing distance from the shore. Common herbs include Maianthemum canadense and Cornus canadensis among species of Gramineae with a ground cover of feather mosses or Sphagnum spp.

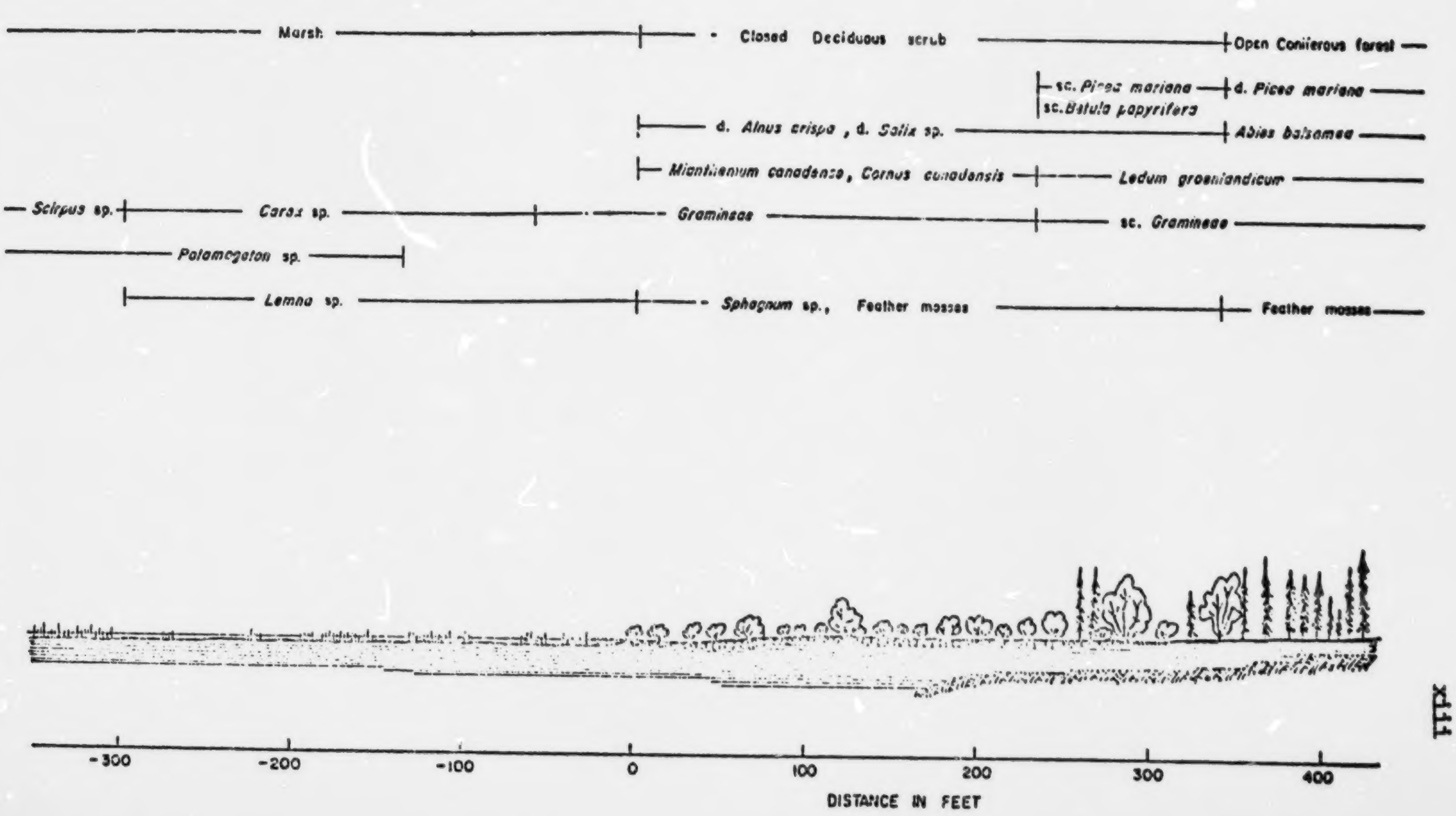
Various communities may occur on the slopes beyong the willow zone; that depicted on the drawn profile must not be treated as other than one case among many.

Shorelines of Type 28 and 28m are most common the Upper Nelson River, but occur throughout the area mapped. They are normally of little areal extent.

FIGURE iV

CLASSIFICATION 28m

LOW WILLOW SHORELINE


Marsh
Closed Deciduous scrub
Open Coniferous forest
sc. Picea mariana
sc. Betula papyrifera
d. Picea mariana
d. Alnus crispa, d. Salix sp.
Abies balsamea
Mianthemum canadense, Cornus canadensis
Ledum groenlandicum
Scirpus sp.
Carex sp.
Gramineae
sc. Gramineae
Potamogeton sp.
Lemna sp.
Sphagnum sp., Feather mosses
Feather mosses
ELEVATION IN FEET
60
40
20
0
-20
-300
-200
-100
0
100
200
300
400
DISTANCE IN FEET

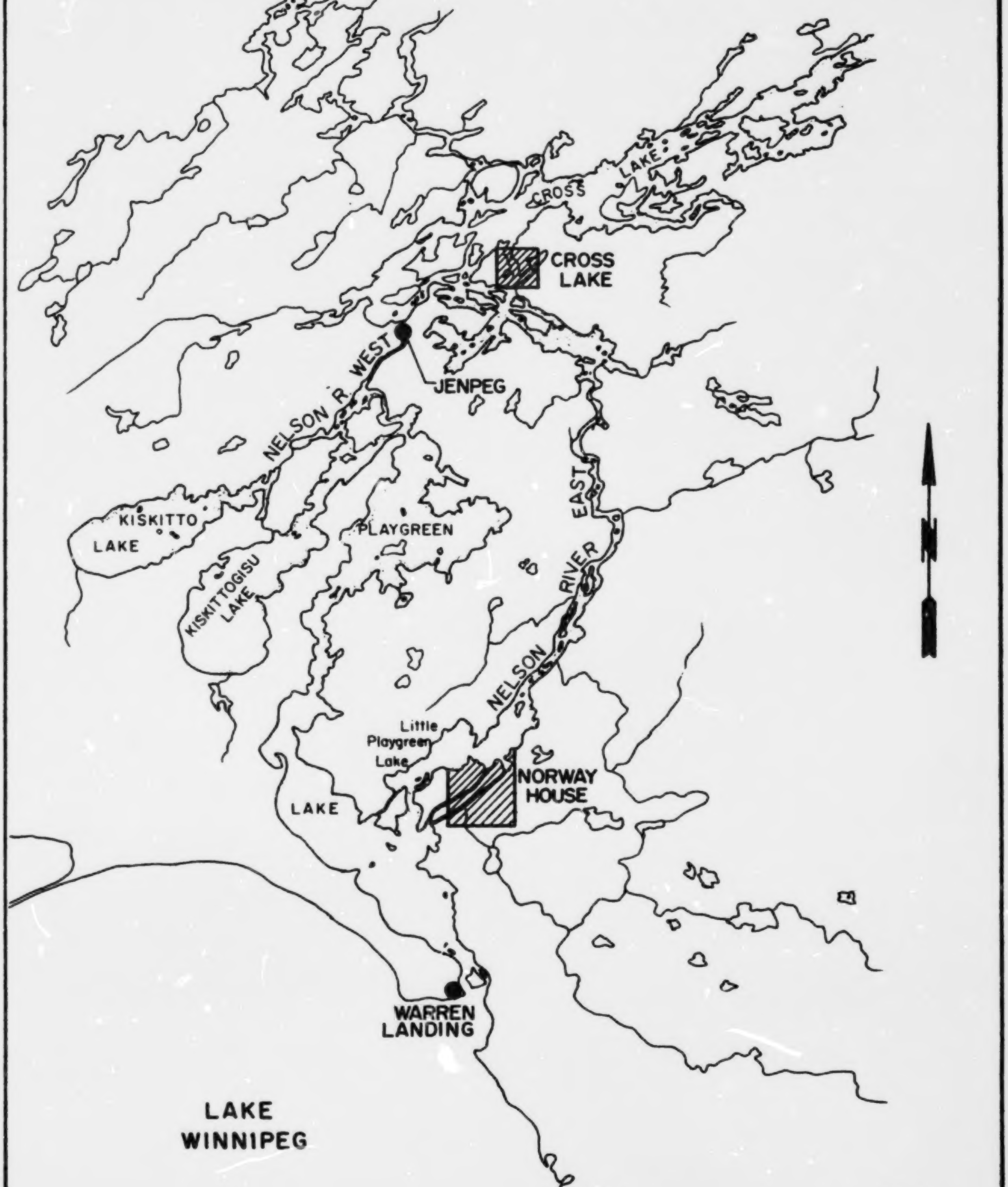

CROSS
LAKE
CROSS
LAKE
JENPEG
NELSON R. WEST
KISKITTO
LAKE
KISKITTOGISU
LAKE
PLAYGREEN
NELSON RIVER EAST
NELSON
Little
Playgreen
Lake
LAKE
NORWAY
HOUSE
WARREN
LANDING
LAKE
WINNIPEG
N

FIG. 1

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA - MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

CROSS LAKE COMMUNITY
LOCATION PLAN

PREPARED T.C.
DRAWN S.P.
CHECKED F.P.
SUBMITTED F.P.
DATE JAN 74
APPROVED
DATE JAN. 74
SCALE N.T.S.
DATE JAN. 74
SHEET 1 OF 12
FILE NO. 54-1-1011

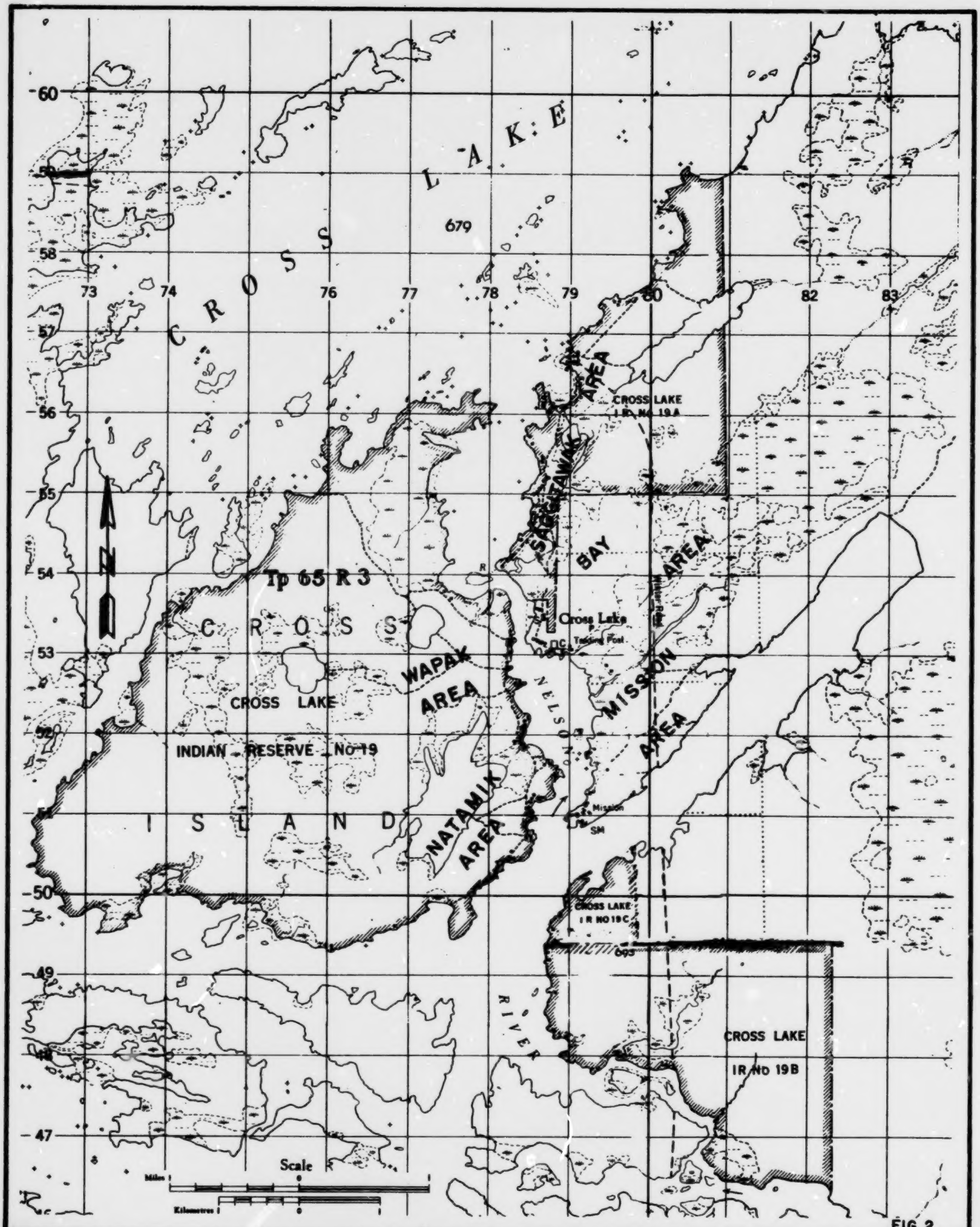

CROSS LAKE
679
73
74
76
77
78
79
80
82
83
60
59
58
57
56
55
54
53
52
51
50
49
48
47
N
CROSS LAKE I.R. No 19 A
SAGATAWAK AREA
BAY
Tp 65 R 3
CROSS
Cross Lake
Trading Post
WAPAK AREA
CROSS LAKE
INDIAN RESERVE No 19
ISLAND
MISSION AREA
MISSION AREA
NATAMIX AREA
NELSON
Mission
SM
CROSS LAKE I R NO 19 C
693
NELSON RIVER
CROSS LAKE IR No 19B
Scale
Miles
Kilometres

FIG. 2

PROVINCE OF MANITOBA

DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

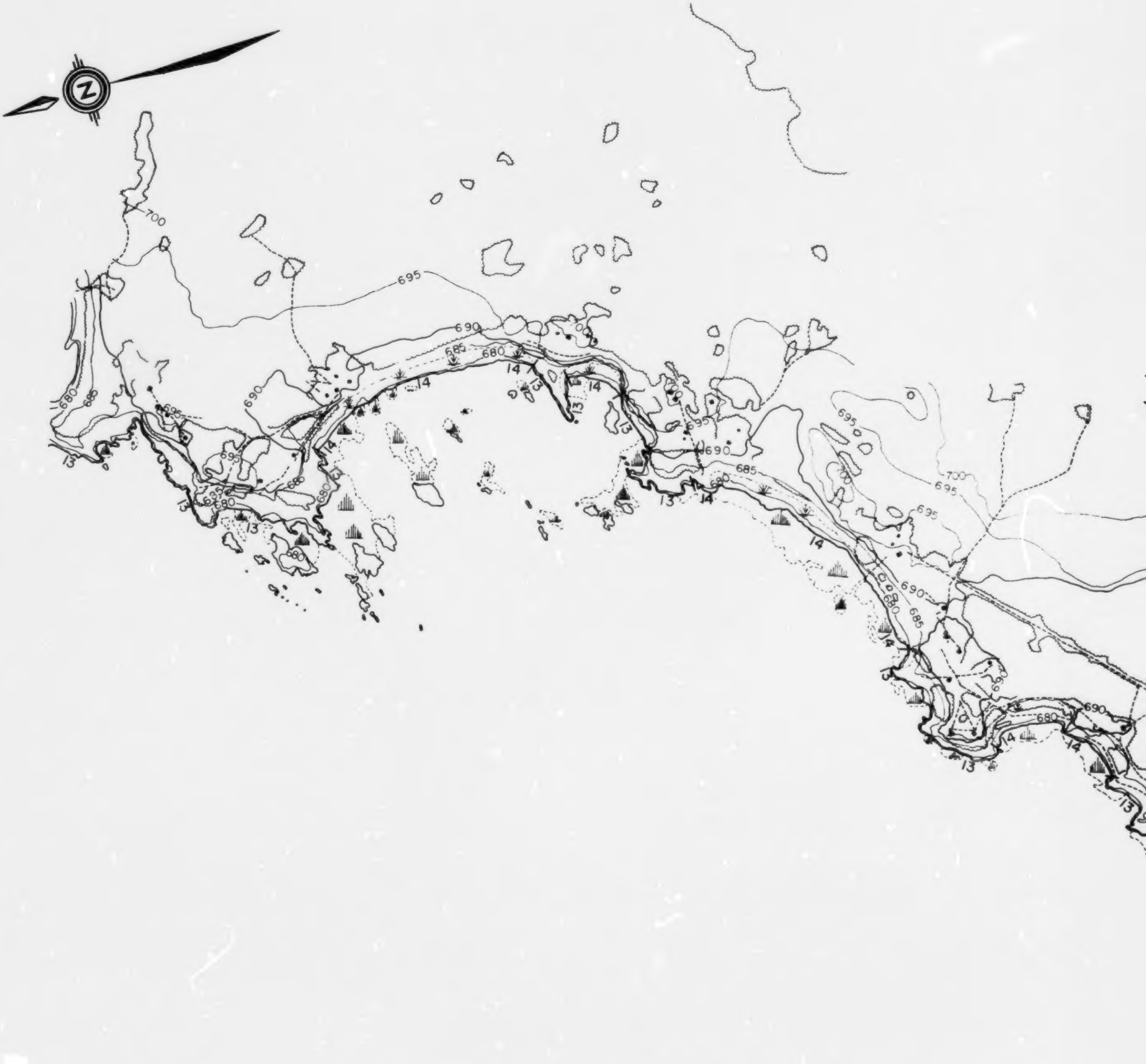
WATER RESOURCES BRANCH

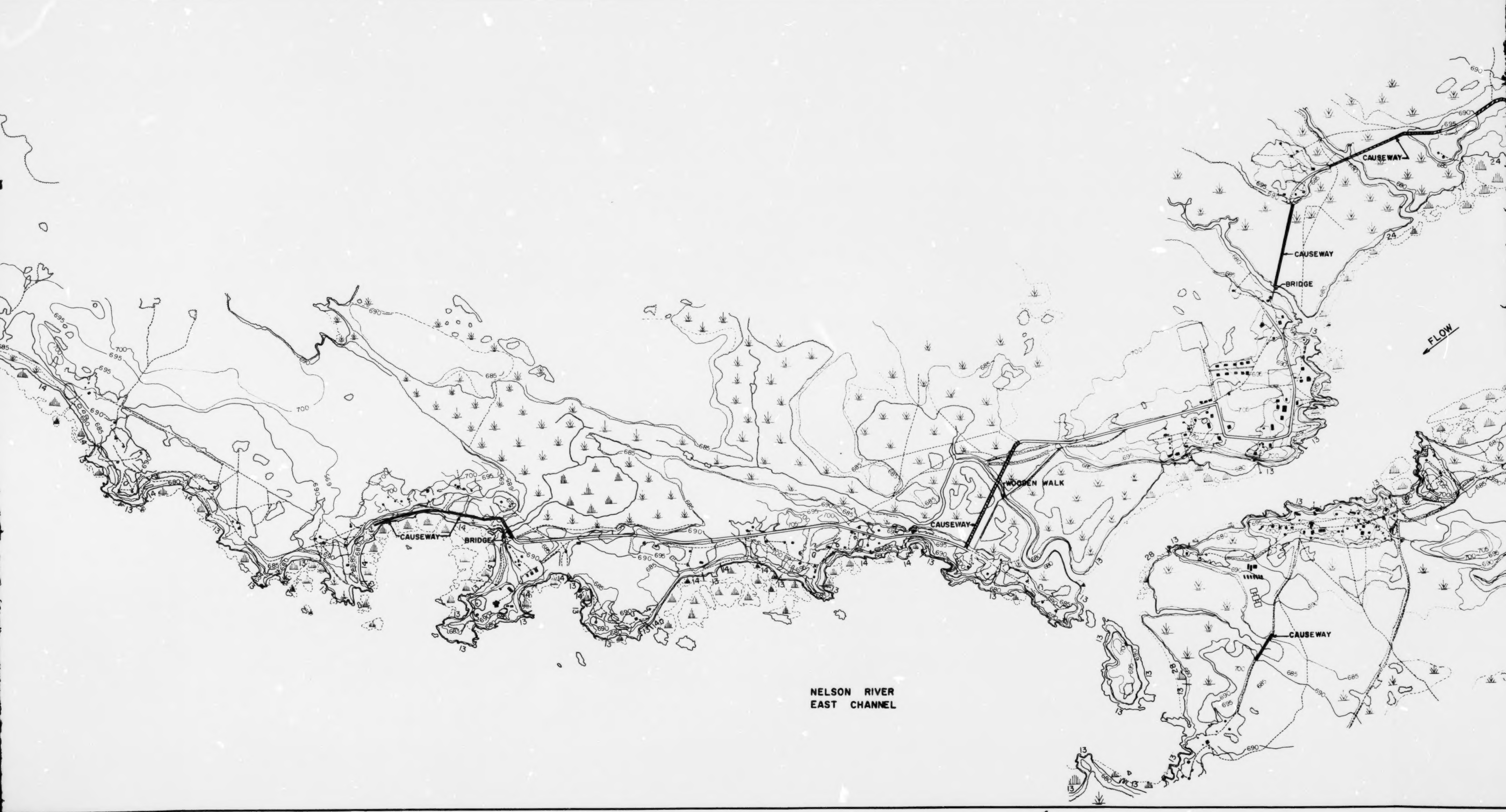
CANADA - MANITOBA

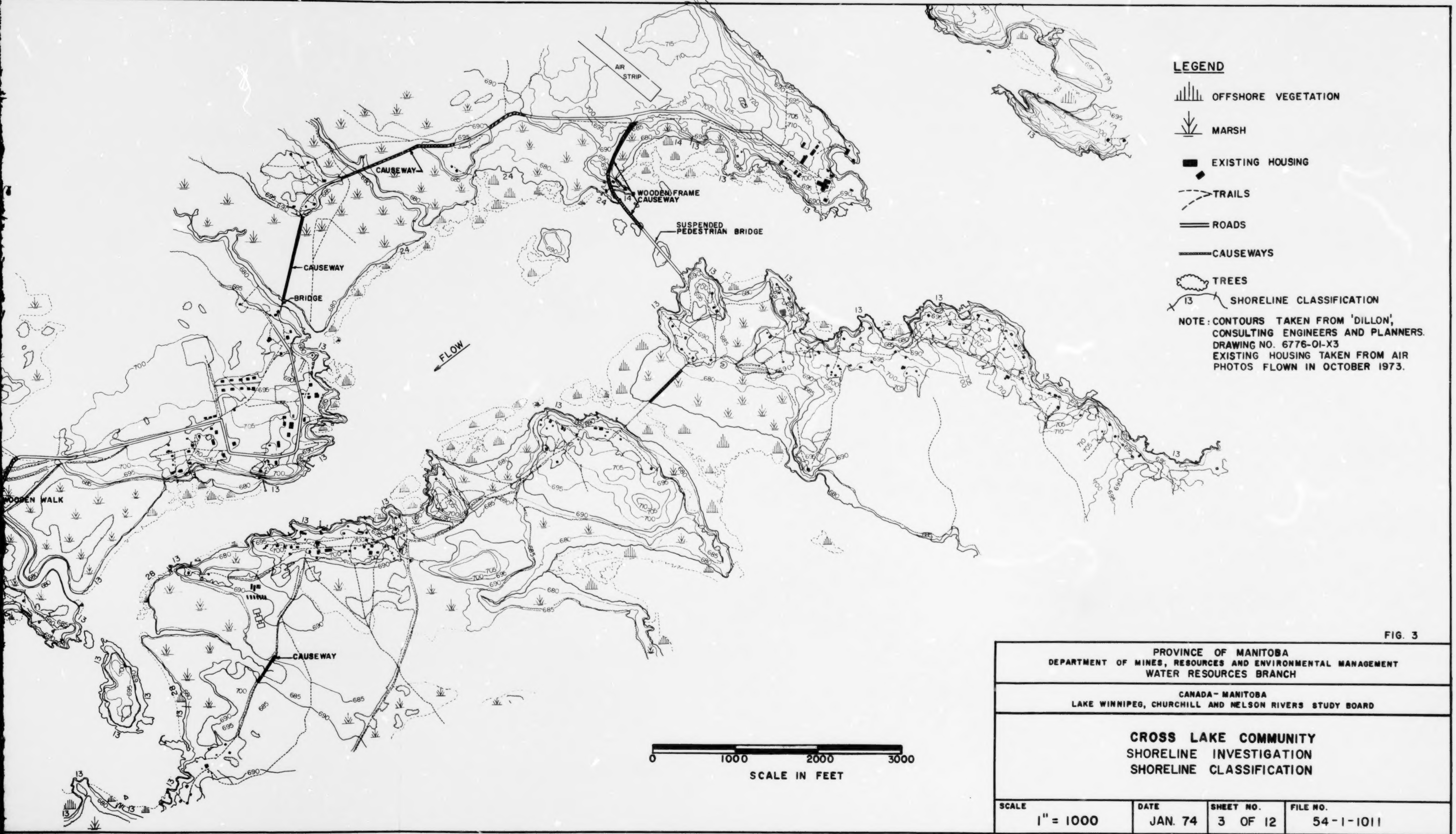
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

CROSS LAKE COMMUNITY
SITE PLAN

PREPARED T.C.	DRAWN S.P. CHECKED F.P.	SUBMITTED DATE JAN. 74	APPROVED DATE JAN. 74	SCALE AS SHOWN	DATE JAN. 74	SHEET 2 OF 12	FILE NO. 54-1-1011


N
700
695
690
685
680
13
14
690
685
680
695
700
695
690
685
680
13
14


CAUSEWAY
BRIDGE
CAUSEWAY
WOODEN WALK
CAUSEWAY
BRIDGE
CAUSEWAY
CAUSEWAY
FLOW
NELSON RIVER
EAST CHANNEL
685
690
695
700
705
13
14
24
28


AIR STRIP
CAUSEWAY
WOODEN FRAME CAUSEWAY
SUSPENDED PEDESTRIAN BRIDGE
CAUSEWAY
BRIDGE
FLOW
WOODEN WALK
CAUSEWAY
LEGEND
OFFSHORE VEGETATION
MARSH
EXISTING HOUSING
TRAILS
ROADS
CAUSEWAYS
TREES
13 SHORELINE CLASSIFICATION
0
1000
2000
3000
SCALE IN FEET

NOTE: CONTOURS TAKEN FROM 'DILLON', CONSULTING ENGINEERS AND PLANNERS. DRAWING NO. 6776-01-X3
EXISTING HOUSING TAKEN FROM AIR PHOTOS FLOWN IN OCTOBER 1973.

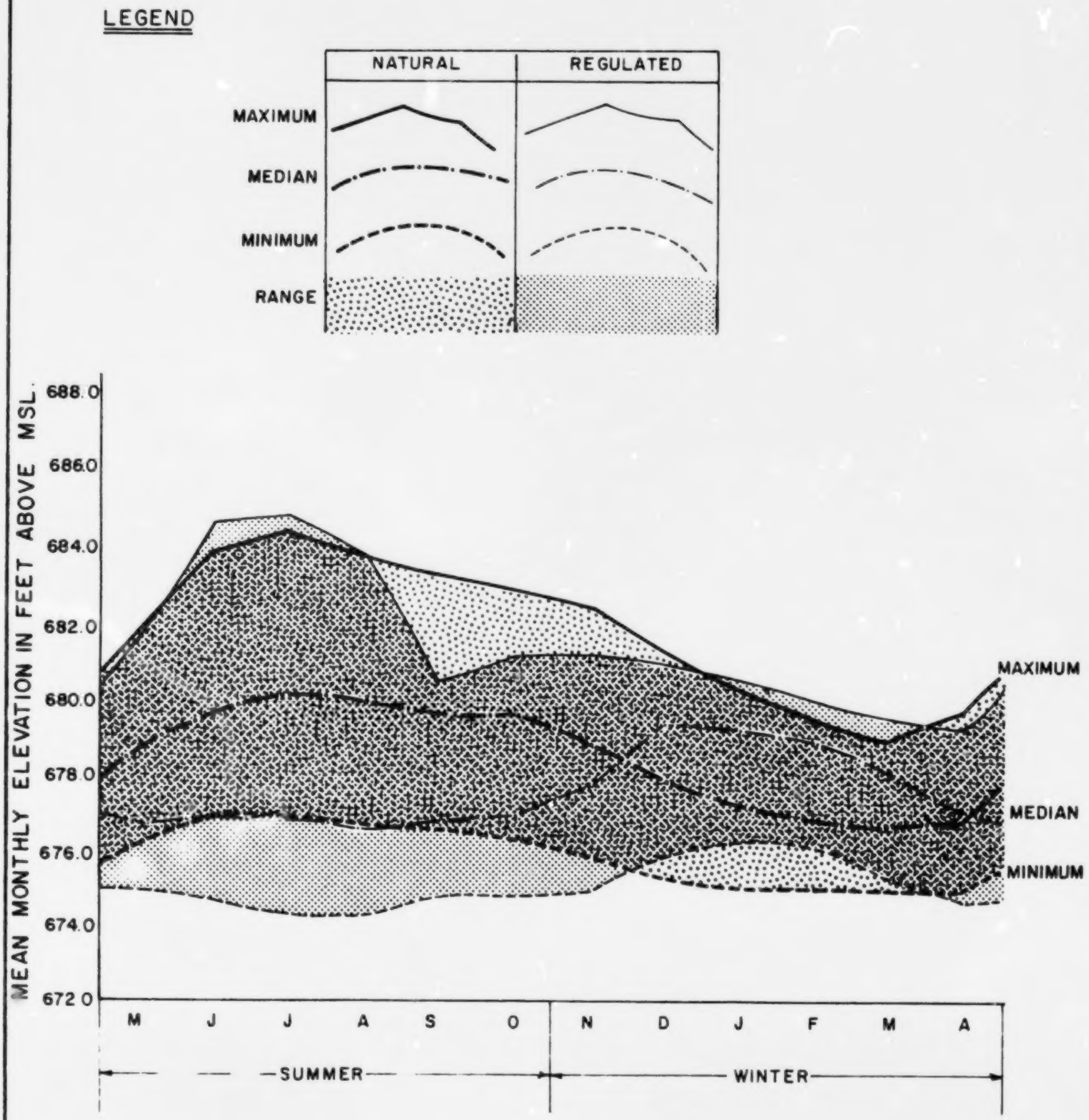
FIG. 3

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA- MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

CROSS LAKE COMMUNITY
SHORELINE INVESTIGATION
SHORELINE CLASSIFICATION

SCALE	DATE	SHEET NO.	FILE NO.
1" = 1000	JAN. 74	3 OF 12	54-1-1011



NOTE CROSS LAKE COMMUNITY DATUM.

FIG. 4

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA - MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

CROSS LAKE COMMUNITY
WATER SURFACE ELEVATIONS

PREPARED T.C.	DRAWN S.P	SUBMITTED	APPROVED
	CHECKED F.P.	DATE JAN. 74	DATE JAN. 74

SCALE AS SHOWN	DATE JAN. 74	SHEET 4 OF 12	FILE NO. 54-1-1011

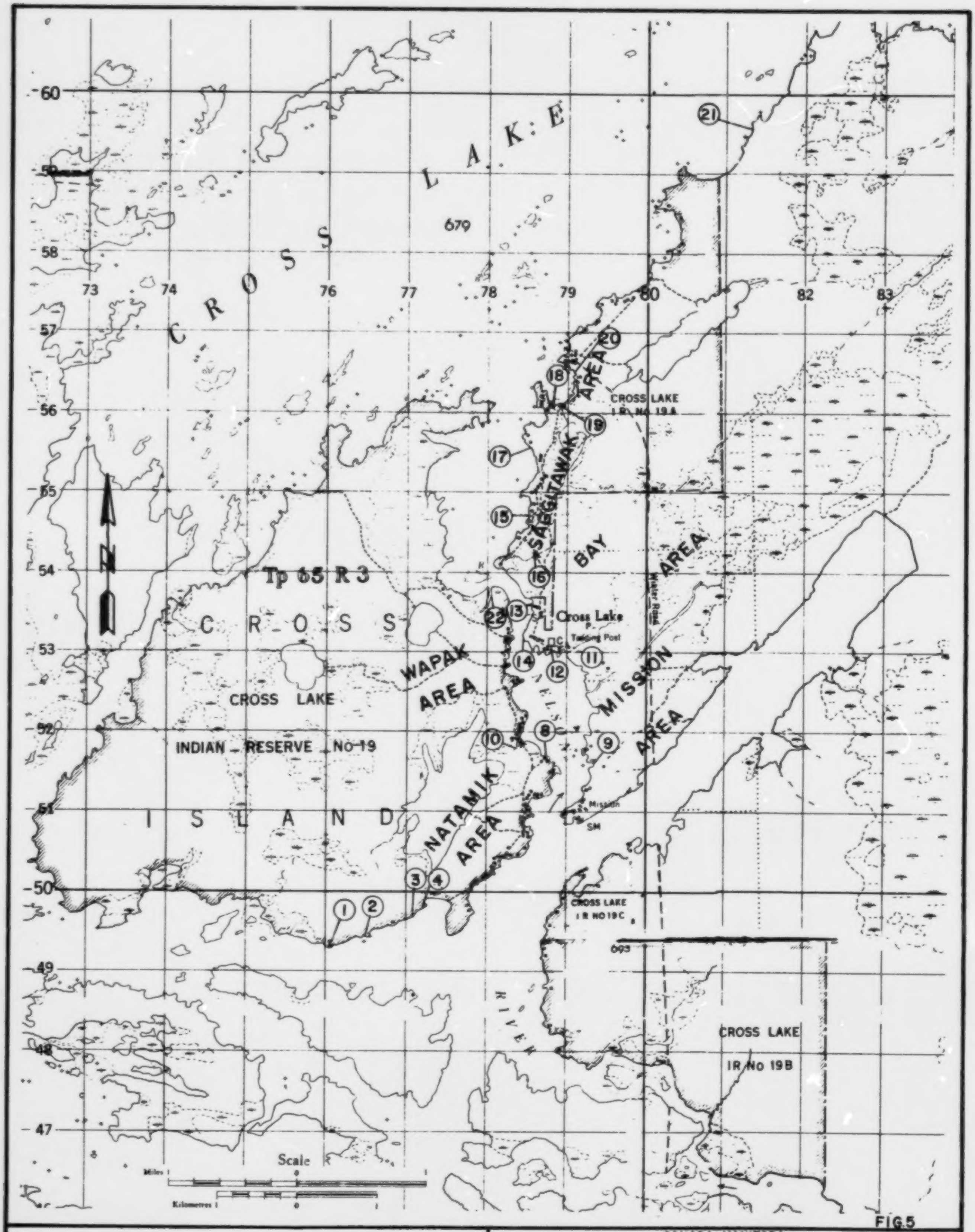

CROSS LAKE
679
Tp 65 R 3
CROSS ISLAND
CROSS LAKE
INDIAN RESERVE No 19
WAPAK AREA
NATAMIK AREA
SAGITAWAK AREA
BAY
MISSION AREA
Cross Lake
Trading Post
Mission
SM
Water Road
CROSS LAKE
IR No 19A
CROSS LAKE
IR NO 19C
CROSS LAKE
IR No 19B
693
RIVER
1
2
3
4
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
60
59
58
57
56
55
54
53
52
51
50
49
48
47
73
74
76
77
78
79
80
82
83
Scale
Miles
Kilometres

FIG.5

PROVINCE OF MANITOBA

DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

WATER RESOURCES BRANCH

PREPARED	DRAWN	SUBMITTED	APPROVED
T.C.	S.P.		
	CHECKED F.P.	DATE JAN. 74	DATE JAN. 74

CANADA - MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

CROSS LAKE COMMUNITY
STUDY SITE PLAN
NO'S 1-4 AND 8-22

SCALE	DATE	SHEET	FILE NO.
AS SHOWN	JAN. 74	5 OF 12	54-1-1011

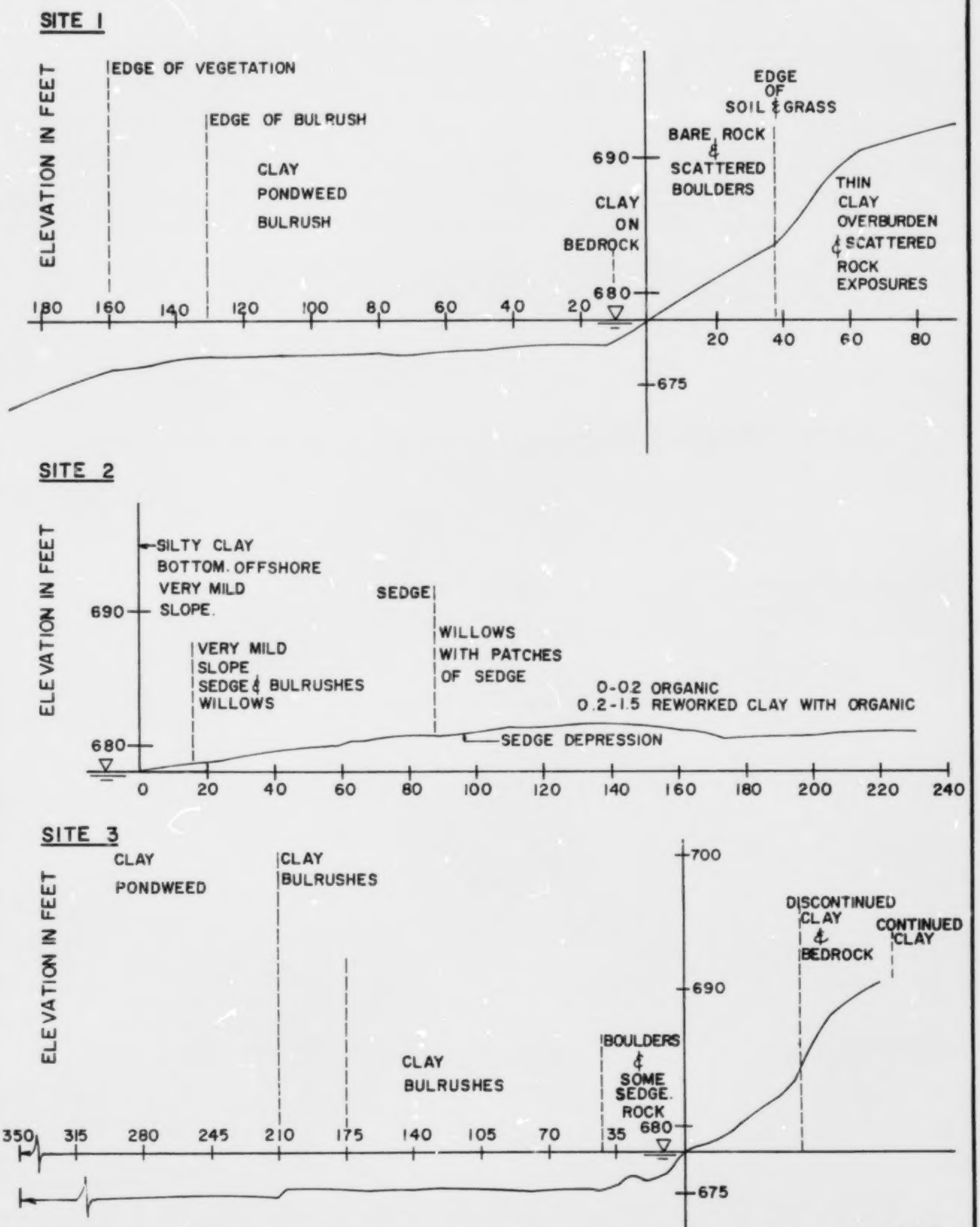


FIG. 6

PROVINCE OF MANITOBA

DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

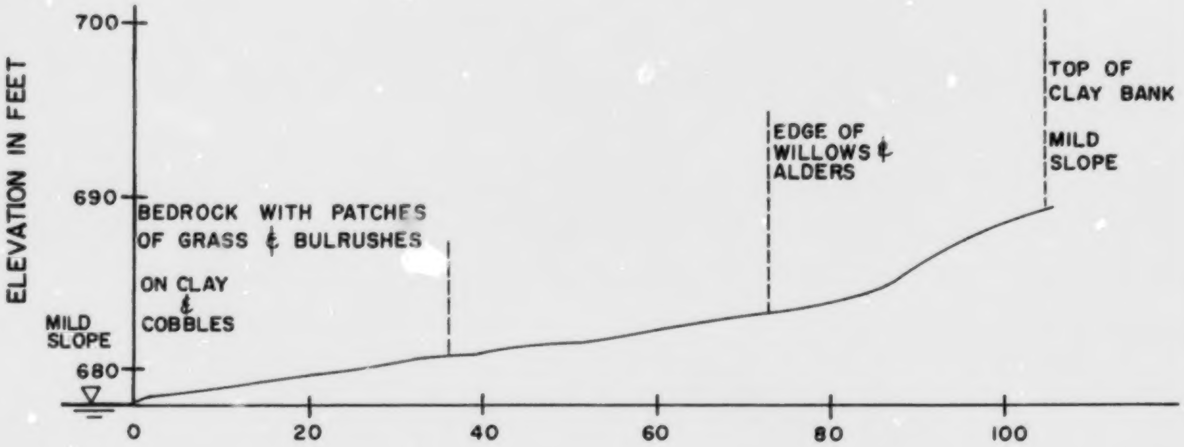
WATER RESOURCES BRANCH

CANADA - MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

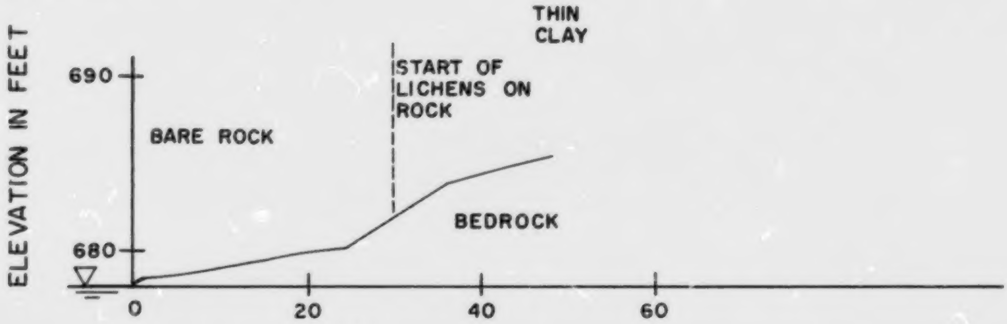
CROSS LAKE COMMUNITY
PROFILES
SITES 1, 2, 3

PREPARED	DRAWN	SUBMITTED	APPROVED	SCALE	DATE	SHEET	FILE NO.
T.C.	S.P.			AS SHOWN	JAN. 74	6 OF 12	54-1-1011
	CHECKED F.P.	DATE JAN. 74	DATE JAN. 74				

SITE 4



SITE 8



SITE 9 A-A

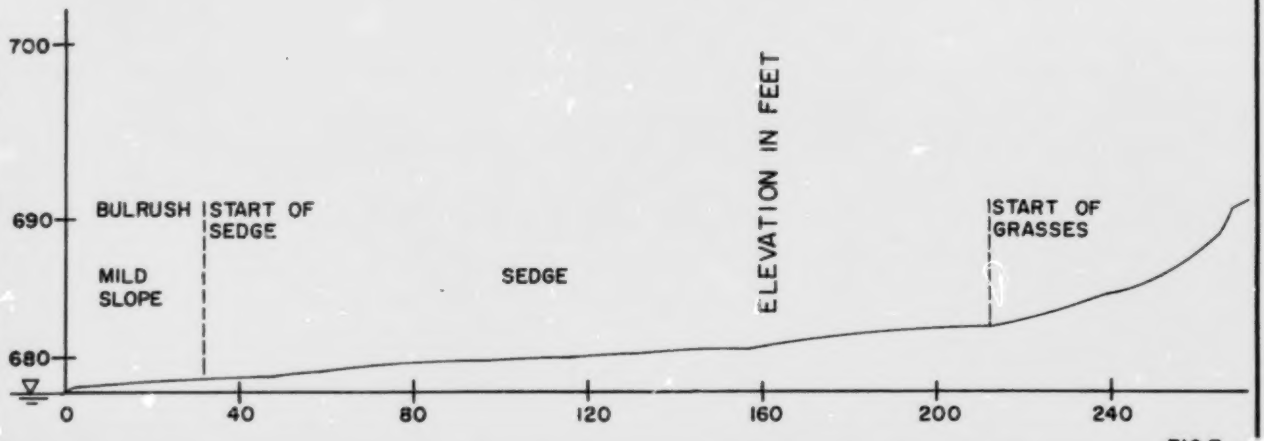


FIG.7

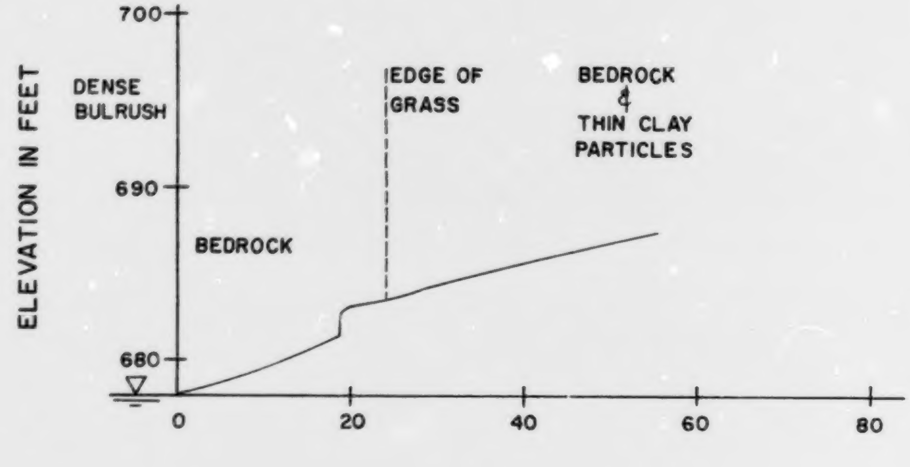
PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

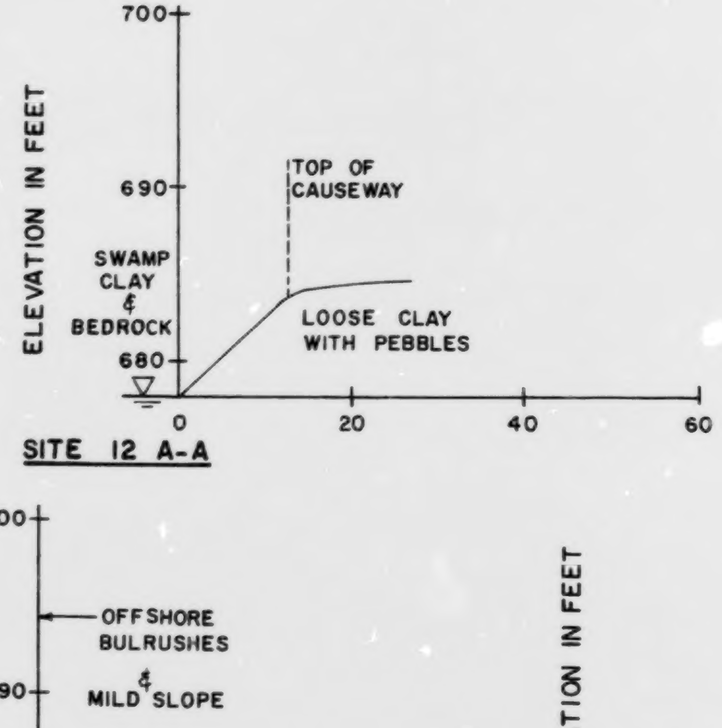
CROSS LAKE COMMUNITY
PROFILES
SITES 4, 8, 9 A-A

PREPARED T.C.	DRAWN S.P. CHECKED F.P.	SUBMITTED F P DATE JAN. 74	APPROVED DATE JAN. 74	SCALE AS SHOWN	DATE JAN. 74	SHEET 7 OF 12	FILE NO. 54-1-1011

SITE 10



SITE 11



SITE 12 A-A

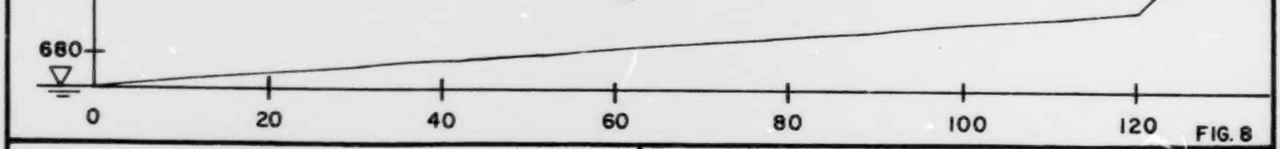


FIG. 8

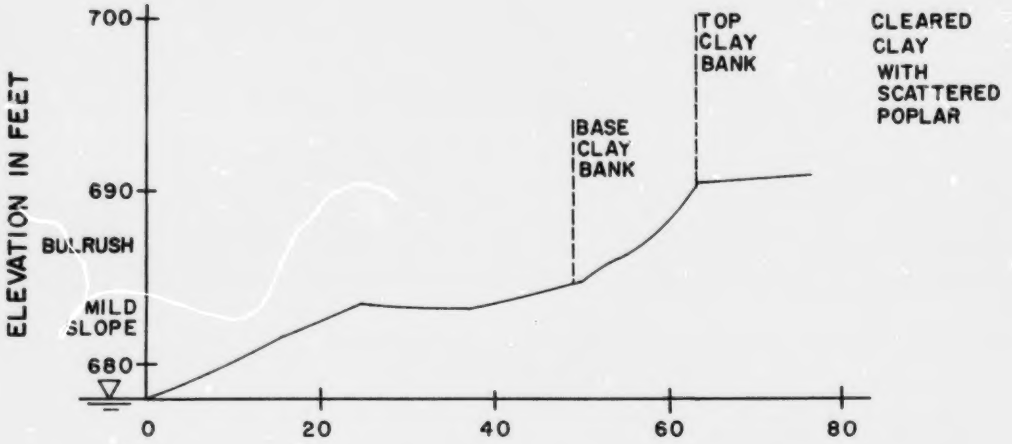
PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG CHURCHILL AND NELSON RIVERS STUDY BOARD

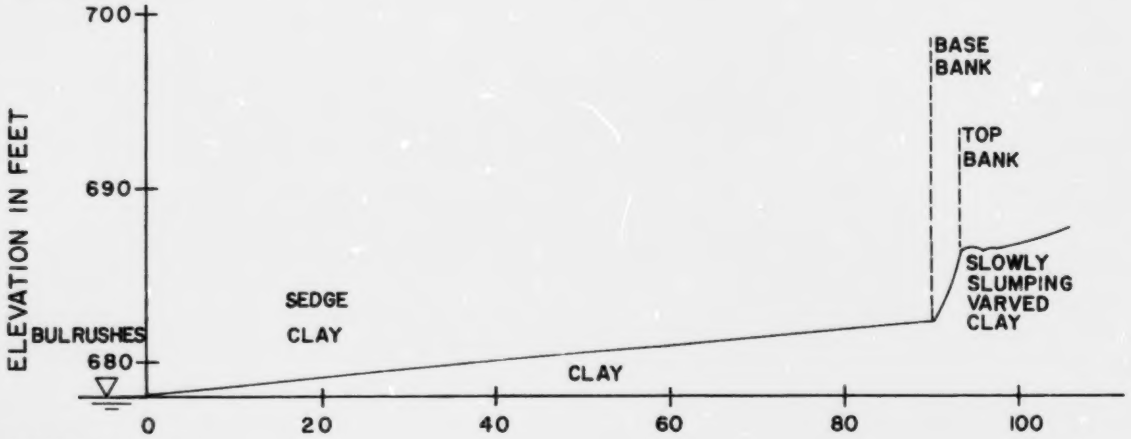
CROSS LAKE COMMUNITY
PROFILES
SITES 10, 11, 12 A-A

PREPARED	DRAWN	SUBMITTED	APPROVED	SCALE	DATE	SHEET	FILE NO.
T.C.	S.P. CHECKED F.P.	DATE JAN. 74	DATE JAN. 74	AS SHOWN	JAN. 74	8 OF 12	54-1-1011

SITE 12 B-B



SITE 12 C-C



SITE 13 A-A

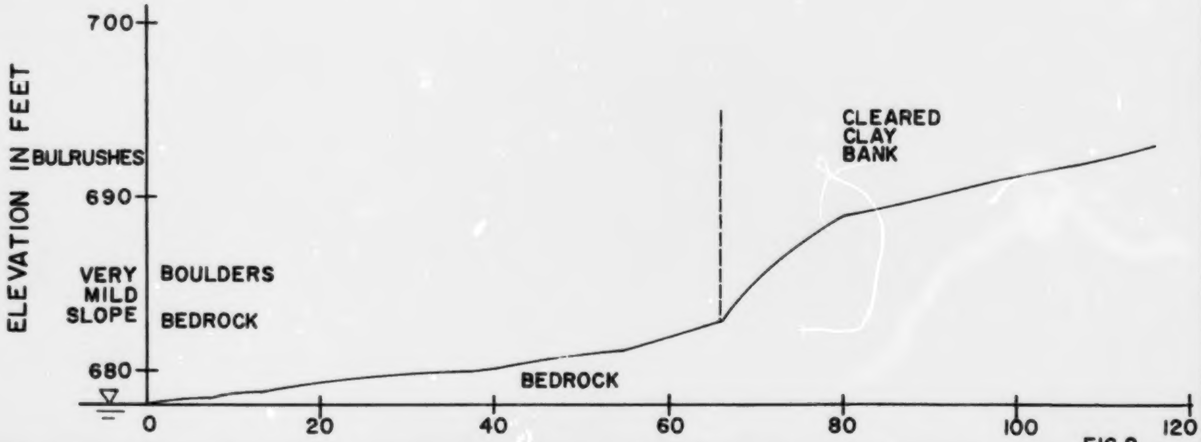


FIG. 9

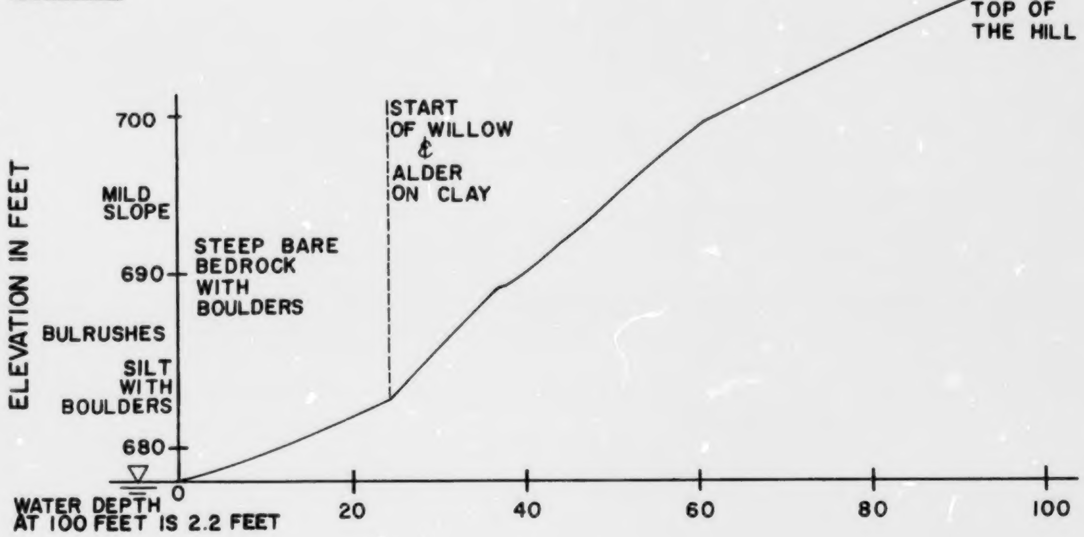
PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA - MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

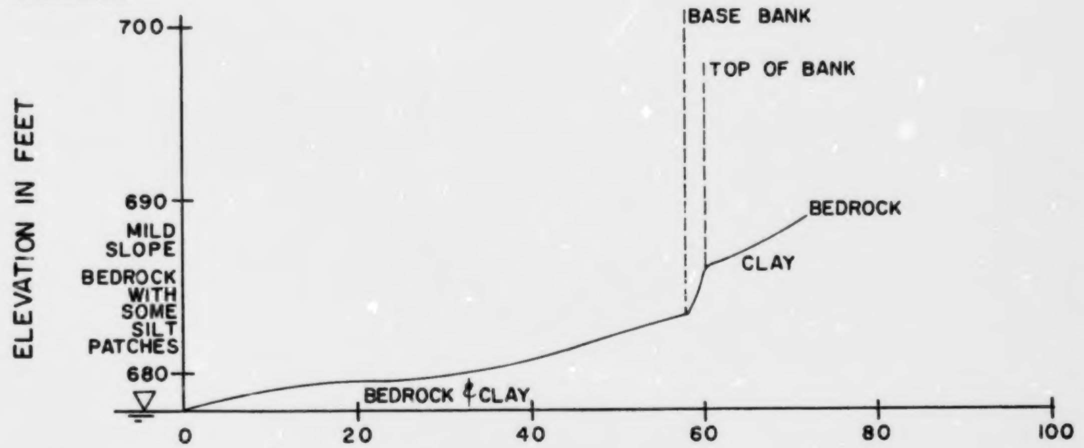
CROSS LAKE COMMUNITY
PROFILES
SITES 12 B-B, 12 C-C, 13 A-A

PREPARED T.C.	DRAWN S.P. CHECKED F.P.	SUBMITTED DATE JAN. 74	APPROVED DATE JAN. 74	SCALE AS SHOWN	DATE JAN. 74	SHEET 9 OF 12	FILE NO. 54-1-1011

SITE 14



SITE 15



SITE 16

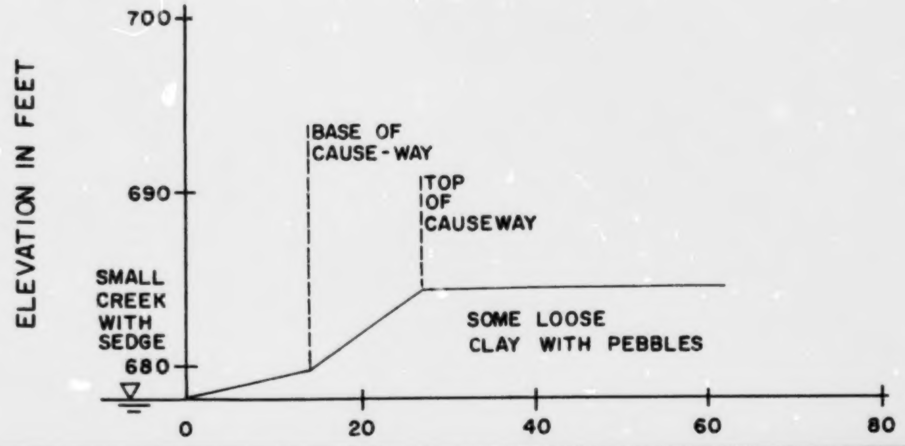


FIG. 10

PROVINCE OF MANITOBA

DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

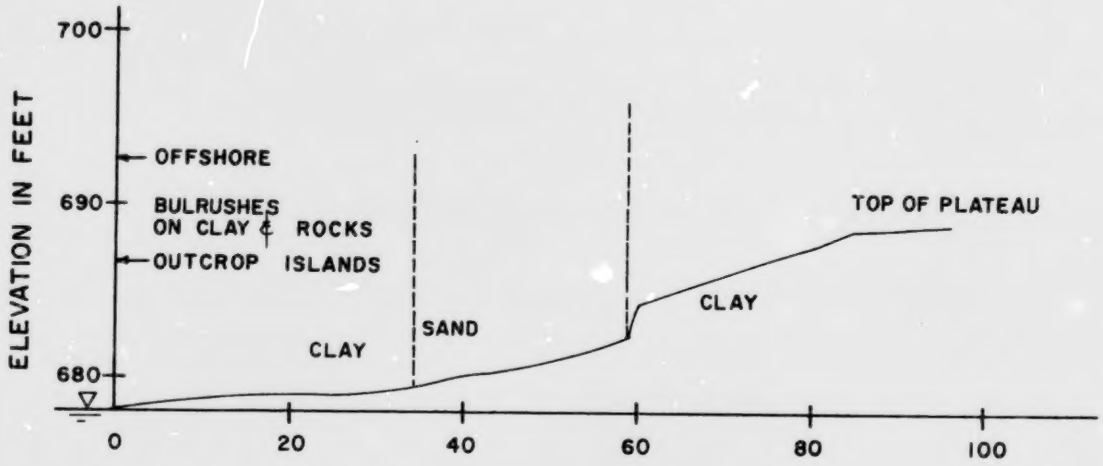
WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

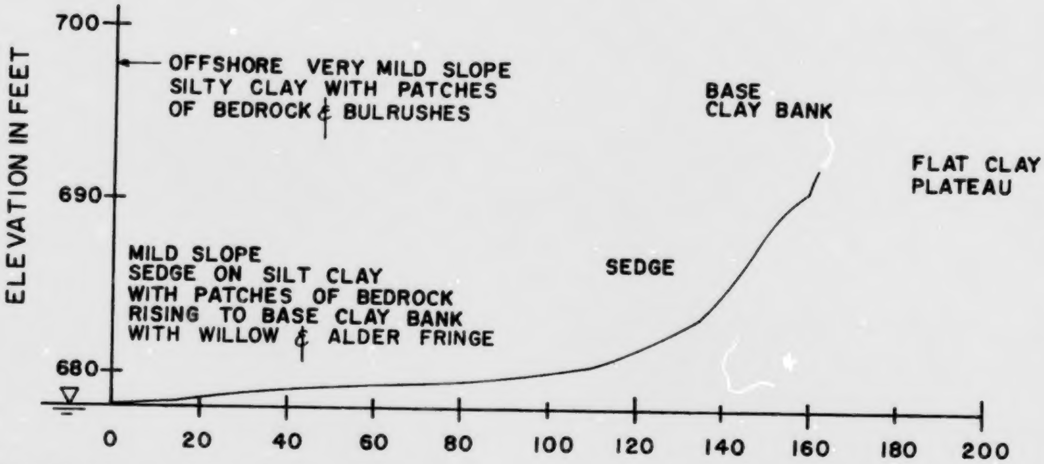
CROSS LAKE COMMUNITY
PROFILES
SITES 14, 15, 16

PREPARED	DRAWN	SUBMITTED	APPROVED	SCALE	DATE	SHEET	FILE NO.
T.C.	S.P. CHECKED F.P.	DATE JAN. 74	DATE JAN. 74	AS SHOWN	JAN. 74	10 OF 12	54-1-1011

SITE 17



SITE 18



SITE 19

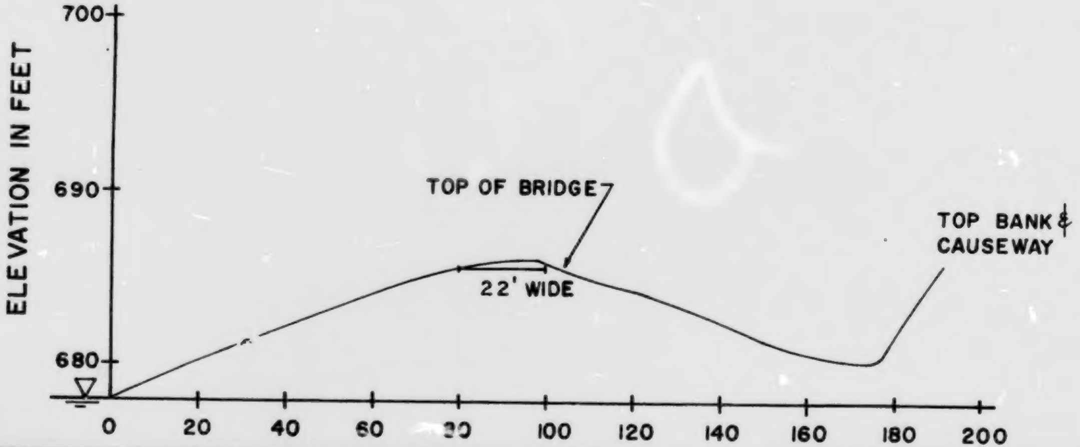


FIG. 11

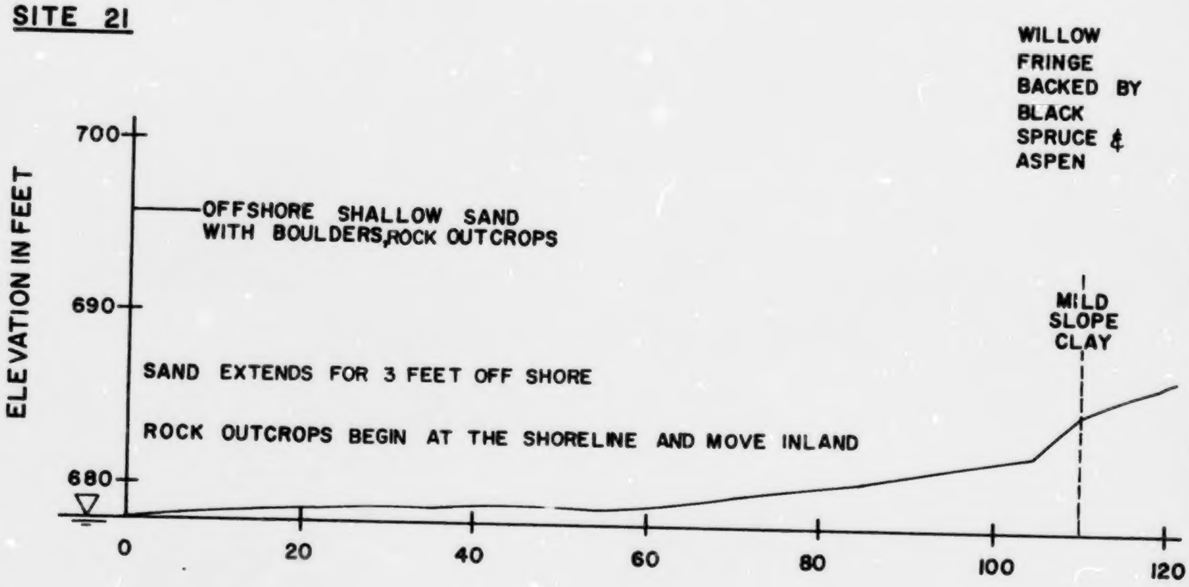
PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

CROSS LAKE COMMUNITY
PROFILES
SITES 17, 18, 19

PREPARED	DRAWN	SUBMITTED		SCALE	DATE	SHEET	FILE NO.
T. C.	S.P.	FP		AS SHOWN	JAN. 74	11 OF 12	54-1-1011
	CHECKED F.P.	DATE JAN. 74	DATE JAN. 74				

SITE 21



SITE 22

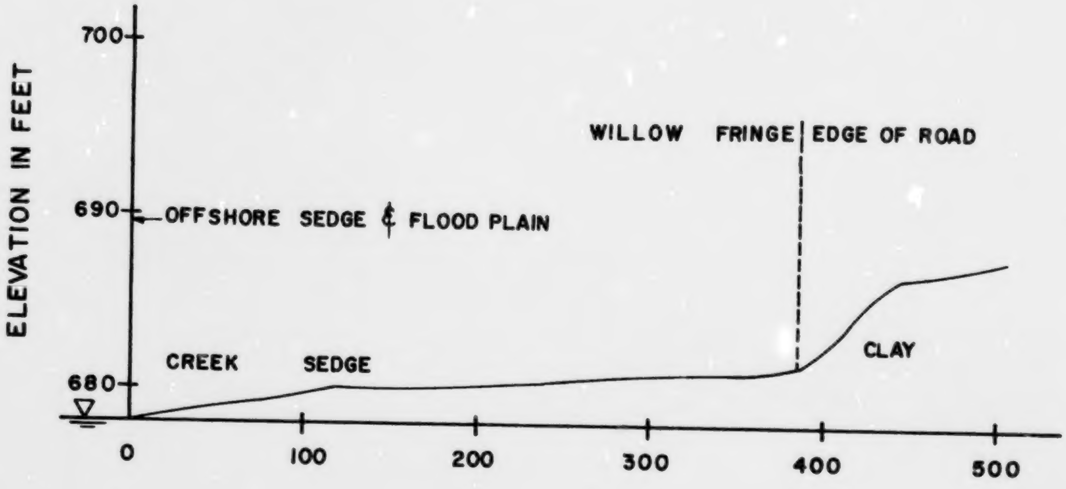


FIG.12

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

CROSS LAKE COMMUNITY
PROFILES
SITES 21 AND 22

PREPARED T.C.	DRAWN S.P. CHECKED F.P.	SUBMITTED FP DATE JAN. 74	APPROVED DATE JAN. 74

SCALE AS SHOWN	DATE JAN. 74	SHEET 12 OF 12	FILE NO. 54-1-1011

APPENDIX 4 - D

REAL PROPERTY ASSESSMENT -
SOUTHERN INDIAN LAKE AND THE
RAT-BURNTWOOD DIVERSION ROUTE

REAL PROPERTY ASSESSMENT
SOUTHERN INDIAN LAKE
AND
RAT-BURNTWOOD DIVERSION ROUTE

by

R. ZIMMERMAN
Planning Division, Water Resources Branch
Manitoba Department of Mines, Resources and Environmental Management
Winnipeg, Manitoba
November, 1973

for

THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SPECIAL NOTE

THE CONCLUSIONS AND RECOMMENDATIONS CONTAINED IN THIS APPENDIX ARE THOSE OF THE AUTHOR(S) AND ARE NOT NECESSARILY THE SAME AS THE CONCLUSIONS AND RECOMMENDATIONS OF THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD AS EXPRESSED IN THE SUMMARY REPORT AND THE TECHNICAL REPORT.

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RECOMMENDATIONS

Further studies are recommended in two areas where, during the course of this study, the assessment of flood damages to real property was not made due to limited field information and pending completion of a separate study at Thompson.

It is recommended that further surveys be undertaken, prior to completion of the diversion, to determine the number of structures which would be affected on Indian Reserves 170A and 170B in the vicinity of Nelson House and whether the cemetery at this location will be endangered.

It is recommended that further investigations be undertaken to facilitate assessment of real property along the Burntwood River near Thompson. This can be completed now that the report on"Effects of Increased Flow in the Burntwood River Near Thompson, Manitoba"by Professor V. Galay and Professor A. Baracas has been published.

INTRODUCTION

The Lake Winnipeg, Churchill and Nelson Rivers Study Board, pursuant to the Terms of an Agreement made the 24th day of August, 1971, between the Governments of Canada and Manitoba relating to the study of probable effects of Manitoba Hydro's projects on water and water related resource uses, has requested the Water Resources Branch to conduct certain investigations regarding Manitoba Hydro's hydro-electric power development schemes. This report contains the results of investigations in the Southern Indian Lake and Churchill River Diversion Route areas concerning flood damages to real property as outlined in the "Flood Damages Study Proposal" of Schedule "A", entitled "Hydrologic, Hydraulic and Geomorphic Proposals", of a Memorandum of Understanding between the Lake Winnipeg, Churchill and Nelson Rivers Study Board and the Water Resources Branch, signed June 14, 1972.

On May 10th, 1973 an Interim License was issued to Manitoba Hydro by the Province of Manitoba "to divert water from the Churchill River into the Nelson River and to impound water on the Rat River and Southern Indian Lake, for the development of water power". The License states that the project shall be completed within five years of the above date and further that during periods when the water level of Southern Indian Lake is above elevation 847 Manitoba Hydro shall "operate the Missi Falls and Notigi control structures in such a manner as to effect the maximum discharge possible under the circumstances then prevailing until the water level of the said lake returns to elevation 847 feet".

Regulation of the water levels on the Lake will cause approximately 70,000 acres around Southern Indian Lake and 90,000 acres upstream of the Notigi control structure on the Rat River to be inundated. In addition, levels will be increased along the Churchill River upstream to Leaf Rapids and for approximately ten miles along the Barrington River.

Within this area are a number of residences, buildings, and fish stations which could be affected by the increased water levels. As well, along the Churchill River diversion route, flooding may have a significant impact on real property.

OBJECTIVES

The purpose of this report is to identify and describe properties which would be affected by flooding and provide an estimate of the anticipated flood damages, to real property, associated with the proposed hydro-electric developments affecting the Churchill, Rat, and Burntwood Rivers.

TERMS OF REFERENCE

This study consisted of an evaluation of properties in two separate areas, the Southern Indian Lake Area, and the Churchill River Diversion Route Area downstream of the Notigi control structure.

Along the diversion route, on the Rat and Burntwood Rivers, the construction of generating facilities is being considered at the following locations: immediately downstream of Wuskwatim Lake; near the junction of the Manasan and Burntwood Rivers; and, at First Rapids on the Burntwood River. Two fish stations which would be affected by the control structure immediately downstream of Wuskwatim Lake have been included in this study. Other properties adjacent to the diversion route which may be affected by the proposed structures have been located and are discussed in this report but no appraisals are made for some of these properties. It is assumed the forebay areas of these potential control structures will be given specific attention when construction of these facilities are anticipated and when all necessary hydraulic information becomes available.

The Community of Split Lake has not been included in this study since changes in flow regime will have a limited effect on lake levels and real property.

STUDY AREAS

Southern Indian Lake Area

This study area includes all that portion of the proposed reservoir upstream of the Missi Falls control structure on Southern Indian Lake and upstream of the Notigi control structure on the Rat River, extending to Leaf Rapids on the Churchill River and approximately ten miles upstream on the Barrington River from Lake Opachuanau.

Diversion Route Area

This study area comprises that portion of the Rat-Burntwood River System downstream of the Notigi control structure.

METHODOLOGY

From July 31, 1972, to August 3, 1972, a reconnaissance survey of the Southern Indian Lake and the Churchill River Diversion Route

Areas was made by an appraiser from the Land Acquisition Branch and an engineer from the Water Resources Branch. Larger fish stations currently in use in the vicinity were personally inspected for purposes of updating the inventory of property which would be directly affected by the water power development scheme. This inventory was prepared by Manitoba Hydro from surveys carried out in 1967. Abandoned sites were inspected from the air to correct the building inventory. The Community of South Indian Lake and the City of Thompson were also visited.

The relevant data obtained from this survey and the previous survey conducted by Manitoba Hydro is presented in Appendix A to this report. Included in Appendix A are: the Appraiser's report; index maps showing locations of camps; descriptions of existing camps; sketches of camp-sites; an inventory of buildings comprising the camps; and selected photographs taken during the reconnaissance survey.

OBSERVATIONS AND CONCLUSIONS

Southern Indian Lake Area

Eighteen fish stations and camp-sites in the Southern Indian Lake Area are described in this report. The fish stations are generally comprised of a fish house for handling the catch, an ice house for storage of lake ice, and accommodation for the fishermen and their families during the season. Often smaller camp-sites adjacent to the fish stations provide these accommodations.

Altogether these sites represent a total of about 105 structures in widely varying degrees of condition and different methods of construction. Twenty of these structures can be considered as ruins. All the buildings are situated on Crown Land.

The stations are utilized on a temporary basis and in a seasonal sequence; that is, the southernmost camps are used earlier in the season and the fishermen move northward on the Lake as the season progresses.

Currently eight fish stations on the Lake are being operated by the South Indian Lake Fisheries Co-operative Ltd. These stations are listed below with their respective camp numbers, as used in Appendix A and on the index maps, as well as the commonly used name of the station:

Camp #1	"North End Fish Camp"
Camp #2	"Duck Narrows"
Camp #5	"Loon Narrows"
Camp #9	"Red Rock Fish Camp"
Camp #11	"Camp No. Nine"
Camp #15	"Camp No. Three"
Camp #16	"Bill Anderson's Fish Camp"
Camp #27	"Opachuanau Fish Camp"

The fish processing plant at Leaf Rapids is also operated by the South Indian Lake Fisheries Co-operative Ltd.

Camp No. 17, "Rat Lake Fish Camp", on Rat Lake is operated by the Nelson House Fisheries Co-operative Ltd.

Eight other fish stations and campsites were recorded in this area. However, most of these sites showed no signs of recent use other than perhaps as a cache for stores.

It must be noted that the majority of these fish stations, both operated by the Co-operatives and privately owned, do not conform to Federal Government regulations governing construction of facilities for the handling and storing of fish destined for human consumption as cited in Schedule A of the Fish Inspection Act and discussed in the Handbook of Compliance pertaining to the construction and operation of fish plants.

In August, 1972, the Southern Indian Lake Fisheries Co-operative Ltd. completed construction of a new fish house and ice house at Loon Narrows to upgrade the facilities at that station to meet these regulations. Construction of similar new facilities are planned at other fish stations operated by the Co-operative where they are required.

The Appraiser's report, which is included in the Appendix to this report, presents reproduction "cost new" figures for each of the fish stations and campsites in both study areas. For sites in the Southern Indian Lake Area, the total reproduction "cost new" value for all the structures, of all types, is about $60,800. In this area there are 51 structures, mostly fish houses and ice houses, below elevation 850. It is estimated that the reproduction "cost new" value of these facilities is of the order of $31,700. Between elevations 850 and 855 there are about 18 structures and it is estimated that the reproduction "cost new" value of these facilities is about $13,900. Between elevations 855 and 860 there are about 10 structures and it is estimated that the reproduction "cost new" value of these structures is of the order of $6,300.

The total reproduction "cost new" value of all structures is divided among the camps in this area as follows:

Camps operated by Southern Indian Lake Fisheries Co-operative Ltd.	$31,600
Camps operated by Nelson House Fisheries Co-operative Ltd.	4,800
Other	24,400
TOTAL	$60,800

The new facilities at "Loon Narrows" are not included in these estimates as they are well above anticipated reservoir levels.

A breakdown of the reproduction "cost new" value of each fish station and campsite is presented in the Appraiser's report presented in Appendix A to this report.

It must be remembered that the reproduction "cost new" value does not represent the value of the structures but is an estimate of replacement costs with similar facilities. To estimate the present physical value of the structures, it would be necessary to subtract depreciation from the replacement "cost new" value figures. The depreciation would range from 30% to 80% depending on remaining useful life and condition of the structure.

The following example is useful in illustrating this situation. In June of 1971 an appraisal of the "Owen Ashley Residence and Fish Camp", Camp No. 13, was made by the Land Acquisition Branch. The replacement cost of the structure at that time was $13,844.69 and the value of the camp after depreciation was subtracted was determined to be $5,155.87. This represented a depreciation factor of about 63%. However, these figures would appear to be on the conservative side as camp No. 13 was purchased by the Province for $2,577.94 subsequent to the 1971 appraisal.

Many of the structures described in this report will be past their useful life and collapsed or otherwise destroyed before they are inundated under the planned sequence of reservoir filling. Assuming no new structures are constructed in areas to be inundated, actual damages to real property in this area at the completion of reservoir filling will be much less than is quoted here.

No costs are presented for docks in the area. It is reported that the majority of log constructed docks are replaced with an almost annual frequency due to the ice break up in spring. Floating docks, it is presumed, would not be damaged during flooding of the reservoir.

During the reconnaissance survey of August, 1972, and from available mapping of the area, note was made of a number of individual cabins and temporary camps in the area around Southern Indian Lake. Locations and remarks concerning these sites are contained in the individual cabins and temporary campsites lists of Appendix A. No attempt was made to determine values or derive replacement costs for these structures and their elevations are unknown. It is obvious in some cases, however, that many of these structures will be damaged by the rising lake levels.

At the Community of South Indian Lake, contour mapping constructed from aerial photographs taken in 1967 shows 12 buildings below elevation 850, 20 buildings between elevations 850 to 855 and 13 buildings between elevations 855 to 860. Construction subsequent to these surveys has for the most part been restricted to higher ground near or above elevation 860. It is estimated that the reproduction "cost new" value of the structures below elevation 850 is about $10,800, between elevation 850 to 855 about $24,000, and between elevations 855 to 860, of the order of $19,600.

In summary, the following reproduction "cost new" values were determined for both the Southern Indian Lake Area and the Community of South Indian Lake:

Elevation	Number of Structures	"Cost new" Value
below 850	63	$42,500
between 850 and 855	38	37,900
between 855 and 860	23	25,900

Diversion Route Area

Two fish stations are located on lakes downstream of the Notigi control structure. Both of these stations are operated by Nelson House Fisheries Co-operative Ltd. One is recorded as Camp No. 25 situated on Wapisu Lake and the other as Camp No. 26 on Wuskwatim Lake. With construction of a generating facility and control structure downstream of Wuskwatim Lake regulating the forebay at about elevation 800 (G.S. of C. Datum) both these fish stations would be completely inundated. The reproduction "cost new" value for these fish stations approximately totals $3,500.

Comments made regarding camps in the Southern Indian Lake Area, pertaining to useful life, depreciation, and the Fish Inspection Act, apply to structures in the Diversion Route Area, as well.

Subsequent to the 1972 reconnaissance survey it was ascertained that a number of individual cabins and a cemetery located along the channel leading from Threepoint Lake to Footprint Lake between Indian Reserves 170A and 170B may be affected by the Diversion. This area would, as well, be in the forebay area of the proposed Wuskwatim control structure. A rating curve available for Threepoint Lake indicates an additional 30,000 cfs. along the Burntwood River would raise the Lake some 13 feet to approximately elevation 801 under open water conditions and a control structure at Wuskwatim Lake with a forebay elevation of 800 would raise the Lake an additional four feet. These increased lake levels would increase water levels along the channel between Threepoint Lake and Footprint Lake. The number of structures, their elevations and the elevation of the cemetery are unknown at this time and therefore an assessment of possible flood damages has not been made for the area.

With anticipated water surface elevations in excess of 804 (G.S. of C. Datum) on Footprint Lake; damages can be expected to a number of structures in the vicinity of Nelson House. Presently, there are about four docks at approximately elevations 785 to 790, fifteen buildings between elevations 795 to 810, and a bridge at about elevation 795. Increased water levels would, as well, inundate numerous existing trails in the vicinity. The reproduction "cost new" value of these structures, not including the docks, is estimated to be about $28,500.

The construction of a generating station, at First Rapids on the Burntwood River, with a forebay elevation of about 610 (G.S. of C. Datum) would, under the maximum licensed flow conditions of approximately 35,000 cfs., result in an elevation of about 616 at the Thompson Bridge and about 618 at the Thompson Pumphouse under open water conditions. Under winter conditions, these elevations could be increased to 630 and 630.5 respectively. Facilities at Thompson that would be affected by increased water surface levels include the Thompson water supply pumphouse with a floor elevation of about 622, the float-equipped aircraft base on the Burntwood River, the sewage treatment plant outfall, and the cemetery.

The report on "Effects of Increased Flow in the Burntwood River near Thompson, Manitoba" by Professor V. Galay and Professor A. Baracos, of the University of Manitoba verifies that the aforementioned facilities would be affected by the raised water levels. This report recommends the following for the above facilities: the raising of the pumphouse floor, the moving of the Air Services buildings to a higher level, the protection of the steep banks near the sewer outfall and the dyking of the cemetery.

CANADA-MANITOBA

LAKE WINNIPEG, CHURCHILL AND

NELSON RIVERS STUDY BOARD

REAL PROPERTY ASSESSMENT

SOUTHERN INDIAN LAKE

RAT-BURNTWOOD DIVERSION ROUTE

APPENDIX A

FISH CAMP LOCATIONS AND DESCRIPTIONS

NOVEMBER, 1973

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INTRODUCTION

From July 31, 1972 to August 3, 1972 a reconnaissance survey of the Southern Indian Lake and Churchill River Diversion Route areas was conducted by personnel working under the auspices of the Lake Winnipeg Churchill and Nelson Rivers Study Board for purposes of updating the inventory of property directly affected by the water power development scheme. The relevant data obtained from that survey and a previous survey conducted by Manitoba Hydro is presented in this Appendix to the Flood Damages Study report.

In the summer of 1967, from June 19 to 28, the General Surveys Section of Manitoba Hydro's Engineering Division completed a survey "to determine the ground elevations at the various fish camps and settlements on Southern Indian Lake and vicinity, to record the size and type of the various buildings, to take photographs and to check for higher ground in the vicinity of the buildings." The results of this survey are reported in Manitoba Hydro Survey Report, Summer, 1967, Book 1, Part 1 of 4, entitled "Elevation Check of Buildings and Fish Camps on Southern Indian Lake and Vicinity", June, 1967.

The following inventory utilises, where possible, Manitoba Hydro's numbering of camp sites and sketches presented in the Summer 1967 Survey Report. Camp sites on Eden Lake, Granville Lake, and Costello Lake (numbers 18 through 23) mentioned in Manitoba Hydro's report are not included in this inventory because they are beyond the extent of anticipated flooding. Also the numbering system has been expanded to accommodate camp sites and buildings found during the 1972 field trip which were not mentioned in the Summer 1967 Survey Report.

In the 1967 survey, Water Resources Branch Bench Mark No. 1492 was used to determine the water surface elevation of Southern Indian Lake. Then by transferring the water surface elevation to each campsite on the Lake elevations of the buildings were approximated. Using Bench Mark No. 1492 it was determined the level of Southern Indian Lake was at an elevation of about 839.5 feet on June 23, 1967. Water Survey of Canada cites the level for that same day as elevation 837.5 feet (G.S. of C.); a difference of two feet exists between the two figures. It has been decided to use the Water Survey of Canada's recorded lake level in this report; therefore, the elevations of buildings determined by Manitoba Hydro's field crew using Bench Mark No. 1492 have been reduced by two feet.

Following is a list and description of the bench marks used in the determination of building elevations and the camps these levels were applied to:

Camps 1 - 16 Southern Indian Lake

Lake Elevation 839.48 feet, June 23, 1967.

(Water Survey of Canada, 837.49 feet, June 23, 1967)

B.M. 1492 (Water Resources Branch)

A 6 inch spike driven horizontally into base of an 8 inch diameter spruce stump approximately 500 feet south of the 23rd base-line and pin #2. Elevation 849.83 feet.

Camp 17 Rat Lake

Lake Elevation 817.38 feet, June 26, 1967

B.M. 64-b-16 (Geodetic Surveys of Canada)

A brass tablet set in a 5 inch spruce stump just north of a small portage on Rat Lake. Stump is on a rock shelf to north-west of portage. Elevation 822.14 feet.

Camp 25 Wapisu Lake

Lake Elevation 784.67 feet, August 19, 1967

B.M. 64-B-10 (Geodetic Surveys of Canada)

A brass tablet set in a 10 inch poplar stump on the south side of the Rat River and about 1000 feet upstream from the confluence of a large stream, also about 2¼ miles from the north end of Wapisu Lake. Elevation 793.26 feet.

Camp 26 Wuskwatim Lake

Lake Elevation 760.35 feet

A brass tablet set in an 8 inch spruce stump on the west side of portage, said portage being on the south-east side of Wuskwatim Lake where the Burntwood River flows out of the Lake. Elevation 790.90 feet.

Camp 27 "Opachuanau Fish Camp"

Elevations were determined using a hand level and the water surface elevation recorded by Water Survey of Canada at South Indian Lake on August 2, 1972.

It should be noted that all elevations quoted in this report are based on the Geodetic Survey of Canada datum.

APPRAISER'S REPORT

The report of the appraiser is contained in a letter from W. Slusar, Property Manager, Land Acquisition Branch, to W. A. Cook, P. Eng., Head, Hydraulic Section, Water Resources Branch, dated October 27, 1972. The full content of the letter follows:

"Further to your letter dated September 14, 1972, and subsequent discussion with yourself, C. Crust and R. Zimmerman, the following is a report covering properties that may be flooded due to Churchill River Diversion.

As was pointed out in our discussions, this is an estimate of present damage only, which is based on spot inspections and the limited information the Appraiser was able to obtain:

Following the initial request to gather this information, there were two courses of action

1. To give a detailed account and an evaluation of each property which would require individual inspection and which would be quite costly,
2. To inspect what looked like representative properties and from information available, project an estimate of probable present value on the properties not visited.

After some consideration, it was decided to follow the second course of action.

To do this, a study was made of reproduction costs on similar properties together with discussions with knowledgeable people who are acquainted with the general area. These reproduction cost new figures used are based on the best information available and within the limited time spent on the study but should be in the ball park.

The reproduction cost new figures were then applied to the properties at each location, totalled, showing an overall reproduction cost new at each location.

With respect to present physical value of the properties or structures, depreciation would range from 30% - 80% depending on remaining useful life and condition of the structure.

In the foregoing, the term "properties" was used and this refers to buildings only, it being assumed all structures are located on Crown Land.

There was no consideration given to docks as it is reported, in general, these are replaced annually. There is the odd exception, but it is felt it was not worthy of consideration for this report.

The following is an estimate, in total, of reproduction costs new, on buildings at each location.

Camp	Total
1	$ 4,255.00
1B	673.00
2	1,110.00
3	NIL
4	1,652.00
5	14,444.00
6	1,923.00
7	3,014.00
8	896.00
9	1,021.00
10	1,468.00
11	3,284.00
12	2,416.00
13	9,246.00
13B	NIL
13C	750.00
14	1,586.00
15	3,312.00
16	1,278.00
16B	793.00
17	4,771.00
25	1,836.00
26	1,613.00
27	2,874.00

SOUTHERN INDIAN LAKE AREA

Description of Camps

Camp #1	"North End Fish Camp"	98°32'W 57°31'N

Operated by South Indian Lake Fisheries Co-operative Ltd. All buildings were in use at the time of the 1967 survey. At the time of the 1972 survey, only the storehouse was in use. The camp was being used as a cache for stores by Leo Linklater, a local fisherman. The land behind the camp rises gradually to an elevation of 862 feet.

Camp #1B

Residence for North End Fish Camp. At the time of the 1967 survey, the camp consisted of three log buildings and a series of tent shacks accommodating about twenty persons. The camp was deserted at the time of the 1972 survey. These buildings are located across the channel to the west of the main camp. The land is quite level near the shore and then rises to above elevation 900 feet behind the camp.

Some abandoned tent frames were found on a point of land east of the North End Fish Camp.

Camp #2	"Duck Narrows"	98°29'W 57°27'N

Operated by South Indian Lake Fisheries Co-operative Ltd. In 1967 this camp was reported to consist of three buildings in poor condition with no signs of recent habitation. Two of these buildings have since collapsed. In 1972 buildings were found on both sides of the narrows, two on the west shore (plus the two collapsed structures) and three on the east shore. There were no signs of recent habitation. The cabins on the east side of the narrows are at an approximate elevation of 853 feet with the land rising above 875 feet further inland on the island. The buildings on the west side of the narrows are at an approximate elevation of 846 feet.

Camp #3 98°20'W 57°26'N

In 1967 this site was described as consisting of a small cabin and a storehouse (refer to 1967 sketch). In 1972 the site was deserted with neither building still standing. The land rises quickly to the north-west of the site and then levels off at about elevation 858 feet.

Camp #4 98°17'W 57°17'N

Two buildings comprise the camp; an equipment shed and a cabin. In 1972 neither building appeared to have been in recent use. It is likely that this location was not a fish camp but a temporary camp of another nature. The land rises behind the cabin to about elevation 880 feet.

Camp #5 "Loon Narrows" 98°32'W 57°16'N

Operated by South Indian Lake Fisheries Co-operative Ltd. This is a main fish camp on the lake and at the time of the 1972 survey was used by approximately thirty fishermen. Besides the structures shown in the sketch about four tents were set up in the camp and along the shore at the time of the visit. The land behind the camp continues to rise to an elevation of about 885 feet. In August, 1972, a new fish house and a new ice house were constructed east of the main camp.

Camp #6 98°25'W 57°10'N

The camp was deserted at the time of the 1967 survey but appeared to have been in recent use. In 1972 the camp was also deserted with no signs of recent use. Three of the houses have collapsed in the intervening years and the remaining buildings are in poor condition. The height of land varies between 850 feet and 860 feet.

Camp #7 98°24'W 57°7'N

In 1972 the camp seemed not to have been in recent use, the large ice house noted in 1967 had collapsed and the dock has since fallen into disrepair.

Camp #8 98°35'W 57°4'N

The camp is situated on a relatively flat island. The main buildings are near the height of level high ground, elevation 855 feet. In 1972 only two houses, buildings D and E remained and the camp seemed not to have been in recent use.

Camp #9 "Red Rock Fish Camp" 99°13'W 57°11'N

Operated by South Indian Lake Fisheries Co-operative Ltd. At the time of the 1967 survey the camp was inhabited by approximately twenty people. The camp was not in use at the time of the 1972 survey. The highest land in the vicinity is around elevation 850 feet.

Camp #10 98°50'W 57°3'N

In 1967 this camp was described as a "well maintained fish house and homes". In 1972 only the fish house and one of the houses, buildings A and C, were found still standing. There is high level land to the rear of the houses up to elevation 873 feet.

Camp #11 "Camp No. Nine" 98°41'W 57°0'N

Operated by South Indian Lake Fisheries Co-operative Ltd. The owners of this camp are reported to be the Clee Brothers. The camp is situated on a rock shelf shore with the land rising steadily to the west of the camp to an elevation of about 867 feet. This camp is one of the main fish stations on the lake.

Camp #12 99°23'W 56°58'N

A small fish station with the residence about a quarter of a mile north of the fish camp. The camp was not in use at the time of the 1972 survey. The highest land nearby is around elevation 862 feet.

Camp #13 "Owen Ashley Residence and Fish Camp" 99°44'W 56°47'N

The camp consists of a small complex of modern buildings at the mouth of the Barrington River. The camp appeared to have been in recent use although it was not occupied at the time of the 1972 survey. The highest elevation nearby is about 875 feet. This camp has been recently purchased from Mr. Ashley and is now owned by the Province.

Camp #13B

A small camp 1½ miles east of Camp #13. The highest land in the vicinity is about elevation 848 feet.

Camp #13C

A house located on an island in the Barrington River, 2 miles west of Camp #13. The house is of log construction; approximately 15 feet by 25 feet and at about elevation 850 feet.

Camp #14 99°25'W 56°47'N

A small fish station located on an island in Southern Indian Lake. The highest land nearby is approximately 100 feet west of the ice house location at elevation 858 feet.

Camp #15 "Camp No. Three" 99°6'W 56°53'N

Operated by South Indian Lake Fisheries Co-operative Ltd. A main fish station located on an island in Southern Indian Lake. The land to the rear of the camp slopes gradually to about elevation 865 feet.

Camp #16 "Bill Anderson's Fish Camp" 98°49'W 56°41'N

Operated by South Indian Lake Fisheries Co-operative Ltd. The camp was inhabited at the time of the 1967 survey but was not in use at the time of the 1972 survey. The houses are half way up a steadily rising slope which reaches an elevation of about 861 feet. Higher land rises steeply a quarter of a mile to the north-east of the camp.

Camp #16B

The camp consists of a fish house and ice house, constructed in 1967, belonging to Bill Anderson. There is a sharp rise of about ten feet directly behind the fish house, and the land levels off to an elevation of around 863 feet.

Camp #17 "Rat Lake Fish Camp" 99°35'W 56°12'N

Operated by Nelson House Fisheries Co-operative Ltd. The camp was inhabited by about ten people at the time of the 1967 survey; but in 1972 was found not to be in use. The buildings are established on a rock shelf with the land rising steeply to the south and less rapidly to the west to an elevation of about 857 feet.

Camp #24 Notigi Lake

In 1967 Manitoba Hydro's survey crew noted that no buildings could be seen from the air where the fish station should have been. They reported sighting an abandoned shack on another location of the lake. In the 1972 reconnaissance a number of individual structures were found at various locations around the lake. These include two abandoned log houses, a collapsed log house and a 4 foot by 4 foot log building. Also, an abandoned Manitoba Hydro camp is located near the outlet of the lake. All of these structures are mentioned in the inventory of individual cabins and temporary camps presented later in this Appendix.

Camp #27 "Opachuanau Fish Camp" 99°34'W 56°44'N

This camp, operated by South Indian Lake Fisheries Co-operative Ltd., has been built since the survey in 1967 and is now one of the main fish stations in the area. Although it was not occupied at the time of the 1972 survey in August, the camp had been used earlier in the season by a number of fishermen.

TABLE 1

SOUTHERN INDIAN LAKE AREA

BUILDING INVENTORY - FISH STATIONS

Camp	Building	Description	Construction	Dimensions (ft.)	Approximate Elevation (ft.)	Remarks
1	A	Fish House	Ply., Conc. Flr.	12 x 24	842	Plus 130' dock
1	B	Ice House	Log	20 x 55	846	
1	C	Ice House	Log	18 x 20	844	
1	D	Store House	Log	12 x 16	846	
1	E	House	Log	16 x 18	846	
1-B	F	House	Log	14 x 18	843	
1-B	G	Tent House	Log Base	12 x 13	843	Missing in 1972
1-B	H	House	Log	13 x 13	864	
1-B	I	House	Log	14 x 18	843	Not shown in 1967 report
1-B	J	Tent House	Log Base		864	Ruin
2	A	House	Log	12 x 12	853	
2	B	House	Log	10 x 15	853	
2	C	House	Log	10 x 15	855	
2	D	House	Log	10 x 15	846	Plus 10' dock
2	E	House	Log	10 x 10	846	
3	A	Cabin	Log	11 x 14	843	Ruin (Neither building)
3	B	Store House		12 x 16	843	Ruin (still standing)
4	A	Equipment Shed	Plywood	12 x 14	843	
4	B	Cabin	Plywood	22 x 14	860	
5	A	Fish House	Frame, Conc. Flr.	15 x 33	841	Plus 125' dock
5	B	Ice House	Frame Const.	20 x 30	842	

TABLE 1 (con't)

SOUTHERN INDIAN LAKE AREA

BUILDING INVENTORY - FISH STATIONS

Camp	Building	Description	Construction	Dimensions (ft.)	Approximate Elevation (ft.)	Remarks
5	C	Equipment Shed	Metal	16 x 18	849	
5	D	House	Frame Const.	24 x 25	858	
5	E	House	Frame Const.	14 x 20	853	
5	F	Garage	Frame Const.	30 x 40	852	
5	G	Shack	Frame Const.	12 x 16	858	
5	H	Shack	Frame Const.	12 x 16	861	
5	I	Shack	Frame Const.	12 x 18	862	
5	J	Fish House	Butler Bld. Conc. Flr.	30 x 60	860	
5	K	Ice House	Bulter Bld.	30 x 60	860	
6	A	Shed	Log	12 x 16	843	
6	B	House	Log	15 x 17	846	Ruin
6	C	House	Log	10 x 12	848	
6	D	House	Log	11 x 13	849	Ruin
6	E	House	Log	8 x 37	852	
6	F	House	Log	13 x 14	852	
6	G	House	Log	10 x 21	847	
6	H	House	Log	10 x 23	851	Ruin
7	A	Fish House	Ply., Conc. Flr.	12 x 16	840	Plus 100' dock - damaged
7	B	Ice House	Log	17 x 18	850	Ruin
7	C	House	Plywood	12 x 32	852	
7	D	Shack	Log	12 x 12	852	
7	E	Shed	Plywood	12 x 16	852	

TABLE 1 (con't)

SOUTHERN INDIAN LAKE AREA

BUILDING INVENTORY - FISH STATIONS

Camp	Building	Description	Construction	Dimensions (ft.)	Approximate Elevation (ft.)	Remarks
8	A	Shack		14 x 14	839	Missing in 1972
8	B	House		12 x 16	840	Ruin
8	C	Shed		16 x 19	852	Missing in 1972
8	D	House	Log	14 x 16	854	
8	E	House	Log	14 x 16	854	
9	A	Fish House	Log	12 x 14	841	Plus 15' x 30' log dock
9	B	Ice House	Log	17 x 19	842	
9	C	Shed	Log	9 x 11	844	
10	A	Fish House	Plywood	14 x 16	839	Plus 60' dock
10 B	B	Ice House		14 x 18	842	Ruin
10	C	House	Log	13 x 22	856	
10	D	House		14 x 15	858	Missing in 1972
10	E	Bombardier Shed		15 x 18	866	Missing in 1972
10	F	Shack		13 x 14	862	Missing in 1972
11	A	Ice House	Log	15 x 15	846	
11	B	House	Log	14 x 20	844	
11	C	House	Log	13 x 25	844	
11	D	Ice House		16 x 18	840	Collapsed log structure
11	E	Fish House	Ply., Conc. Flr.	13 x 21	840	Plus 20' dock
11	G	Shack	Log	10 x 11	845	
12	A	Fish House	Ply., Conc. Flr.	12 x 18	844	Plus 35' dock
12	B	Ice House	Log	15 x 17	845	
12	C	Ice House	Log	17 x 20	850	
12	D	House	Log	15 x 20	853	¼ Mile from main camp

TABLE 1 (con't)

SOUTHERN INDIAN LAKE AREA

BUILDING INVENTORY - FISH STATIONS

Camp	Building	Description	Construction	Dimensions (ft.)	Approximate Elevation (ft.)	Remarks
13	A	Fish House	Ply., Conc. Flr.	12 x 14	839	Plus 50' dock
13	B	Oil Storage Shed	Shiplap Ext., Conc. Flr.	9 x 12	839	
13	C	Ice House	Log, Ply. roof	14 x 16+ 13 x 15	839	
13	D	Store House	Plywood	12 x 16	856	
13	E	Garage	Log	19 x 22	852	
13	F	Bunk House	Plywood	9 x 12	858	
13	G	Power House	Plywood	7 x 7	858	
13	H	Cottage	Plywood & Frame	34 x 37	864	
13	I	Shed	Log	13 x 13	865	
13	J	Bunk House	Plywood & Frame	12 x 20		On high point east of main camp
13	K	Shed		8 x 8		
13-B	L	House		15 x 25	846	
13-B	M	Shed		10 x 10	846	
13-B	N	Shed		5 x 5	846	
13-B	O	Shed		8 x 10	840	
13-C	P	House	Log	15 x 25	850	
14	A	Fish House	Log	13 x 18	839	Plus 40' dock
14	B	Ice House	Log	18 x 18	851	
14	C	House	Log	15 x 20	848	100 yds. north of dock, not mentioned in 1967 report

TABLE 1 (con't)

SOUTHERN INDIAN LAKE AREA

BUILDING INVENTORY - FISH STATIONS

Camp	Building	Description	Construction	Dimensions (ft.)	Approximate Elevation (ft.)	Remarks
15	A	Fish House	Ply., Conc. Flr.	14 x 24	846	Plus 60' dock
15	B	Ice House	Log	20 x 36	846	
15	C	Shed	Log	10 x 13	848	Missing in 1972
15	D	Storehouse	Plywood	12 x 16	848	
15	E	House	Log	12 x 14	848	
16	A	Fish House	Log	11 x 13	839	Plus 40' dock
16	B	Ice House	Log	17 x 18	844	Missing in 1972
16	C	House	Log	16 x 16	850	
16	D	House	Log	15 x 16	850	
16-B	E	Fish House	Ply., Conc. Flr.	10 x 12	839	Plus 25' dock
16-B	F	Ice House	Log	14 x 14	847	
16-B	G	Shack		14 x 14		Missing in 1972
17	A	Fish House and Ice House	Log (Double Walls)	37 x 30 & 12 x 15	824	13' dock missing in 1972
17	B	Storehouse	Log	18 x 38	825	
17	C	House	Log	14 x 17	827	
27	A	Fish House	Ply., Conc. Flr.	12 x 16	847	Plus 50' dock
27	B	Ice House	Log	20 x 40	845	
27	C	(Half Const.) House	Log	12 x 18	860	
27	D	Storehouse	Plywood	10 x 10	855	
27	E	House	Log	12 x 15	851	

Inventory of Individual Cabins and Temporary Camps

Following is a list of individual cabins and their locations in the Southern Indian Lake Area. Also included are the approximate locations of temporary camps set up by Manitoba Hydro in the vicinity of the Lake.

	Description	Location	Remarks
1.	Trappers Cabin	98°25'W 57°12'N	On a small island in Southern Indian Lake
2.	Two Shacks	99°17'W 57°8'N	Near water quality sampling station 4 miles south-west of Camp #9
3.	Cabin	98°38'W 57°38'N	8 miles north-west of Camp #1
4.	Log Cabin	99°23'W 55°56'N	On west shore of Notigi Lake (Green Roof)
5.	Ruined Cabin	99°20'W 55°57'N	Corrugated iron roof can be seen
6.	Cabin	99°20'W 55°57'N	Close to ruin
7.	Log Cabin	99°14'W 55°57'N	(Approx. 4' x 4') on north shore of Notigi Lake
8.	Hydro Camp	98°10'W 57°23'N	At Missi Falls
9.	Hydro Camp	99°22'W 55°56'N	On Notigi Lake
10.	Hydro Camp		On Isset Lake
11.	Hydro Camp		On Barrington Lake

DIVERSION ROUTE AREA

Description of Camps

Camp #25	Wapisu Lake	99°15'W 55°48'N

In 1967 the camp, on an island in Wapisu Lake, was reported to be in use and with all the buildings in reasonably good condition. In 1972 the camp was found unoccupied, the dock was damaged, one house (building A) was missing, and the ice house roof was missing. Two log houses were found on the island south of the main camp. Land is available for relocation at this site up to an elevation of approximately 810 feet.

Camp #26	Wuskwatim Lake	98°35'W 55°31'N

Operated by Nelson House Fisheries Co-operative Ltd. The main camp is located at the south end of the lake with a residence located a few hundred yards to the east. At the second location only one house (building G) remains. The camp was not in use at the time of the 1972 survey. There is no high ground in the vicinity of the camps.

TABLE 2

DIVERSION ROUTE AREA

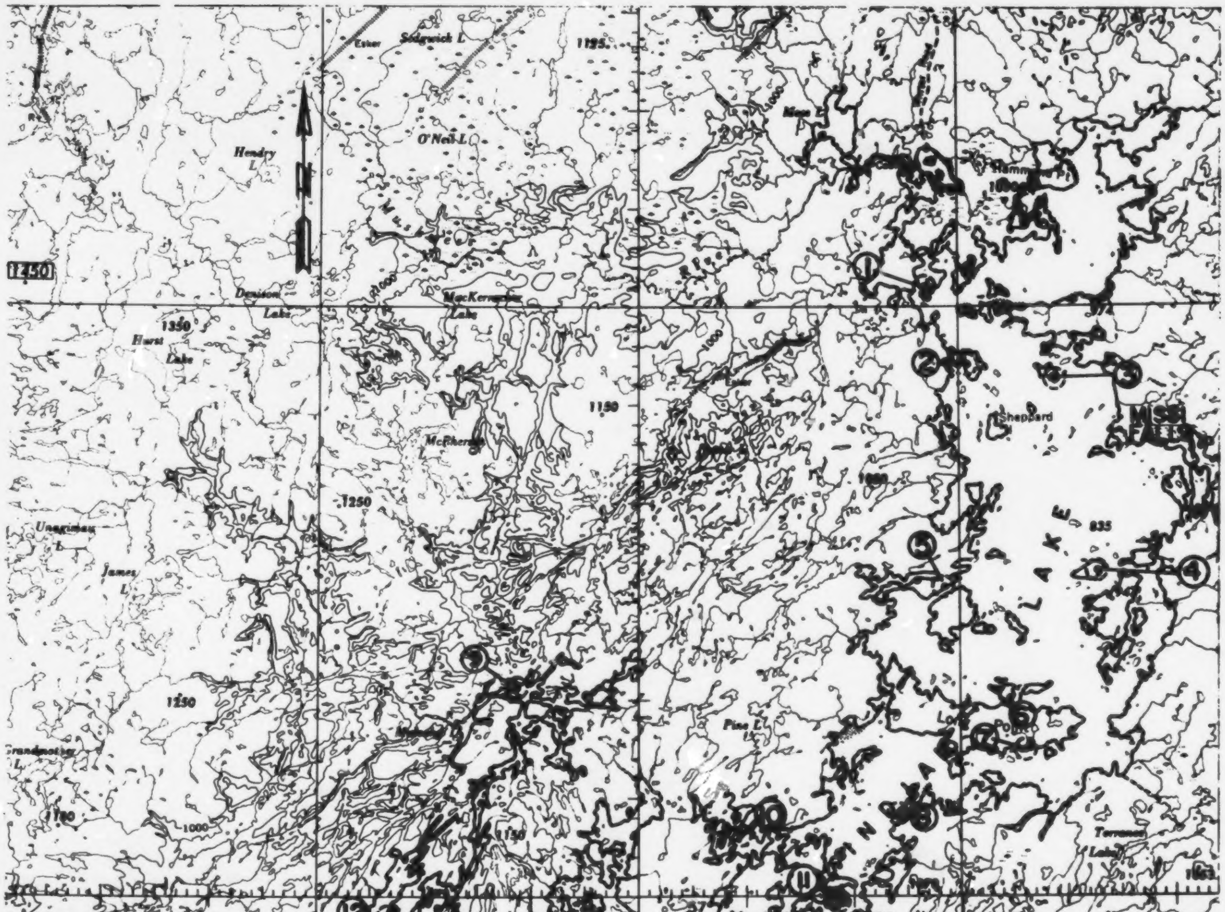
BUILDING INVENTORY - FISH STATIONS

Camp	Building	Description	Construction	Dimensions (ft.)	Approximate Elevation (ft.)	Remarks
25	A	House		12 x 15	790	Missing in 1972
25	B	Fish House	Log	12 x 15	790	Plus 20' dock - damaged
25	C	Ice House	Log	18 x 21	798	
25	D	House	Log	12 x 15		South of main camp
25	E	House	Log	12 x 15		
26	A	Ice House	Log	21 x 23	773	Plus 10' dock
26	B	Att. Fish House	Log	13 x 16	773	
26	C	Shed	Log	12 x 16	774	Missing in 1972
26	D	House	Log	12 x 16	776	
26	E	House	Log	10 x 12	776	On point east of main camp

Inventory of Individual Cabins and Temporary Camps

Following is a list of individual cabins and their locations in the Diversion Route Area. Also included are the approximate locations of temporary camps set up by Manitoba Hydro in the vicinity of the diversion route.

	Description	Location	Remarks
1.	Cottage	Mystery Lake	Owned by H.O. Bear; Elevation approx. 614
2.	Cottage	Mystery Lake	Owned by J. St. Laurent; Elevation approx. 611
3.	Cottage	Mystery Lake	Near H.O. Bear cottage; Elevation approx. 614
4.	"Canico Camp"	Moak Lake	
5.	A number of cabins and a cemetary on I.R. 170A and I.R. 170B on the north shore of Threepoint Lake and the channel between Threepoint Lake and Footprint Lake. Approx. 98°54'W 55°43'N.		
6.	Hydro Camp	on Wuskwatim Lake	
7.	Hydro Camp	on First Rapids	
8.	Unidentified Structure near Manasan Falls		


Sedgwick L.
1125
O'Neil L.
Hendry L.
1450
N
Denison Lake
MacKerracher Lake
Hurst Lake
1350
1250
1150
1000
McPherson
Unagimau L.
James L.
Grandmother L.
1100
Pine L.
Shepard
MISSI FALLS
LAKE
835
Torrance Lake
1150
Cousins L.
Uhlman Lake
SOUTH INDIAN LAKE
South Bay
DIVERSION CHANNEL
Harrington
Opachuanau
RIVER
CHURCHILL
LEAF RAPIDS
Rusty L.
RAT RIVER
1080
Magrath L.
Lemay
836
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

PROVINCE OF MANITOBA

DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

WATER RESOURCES BRANCH

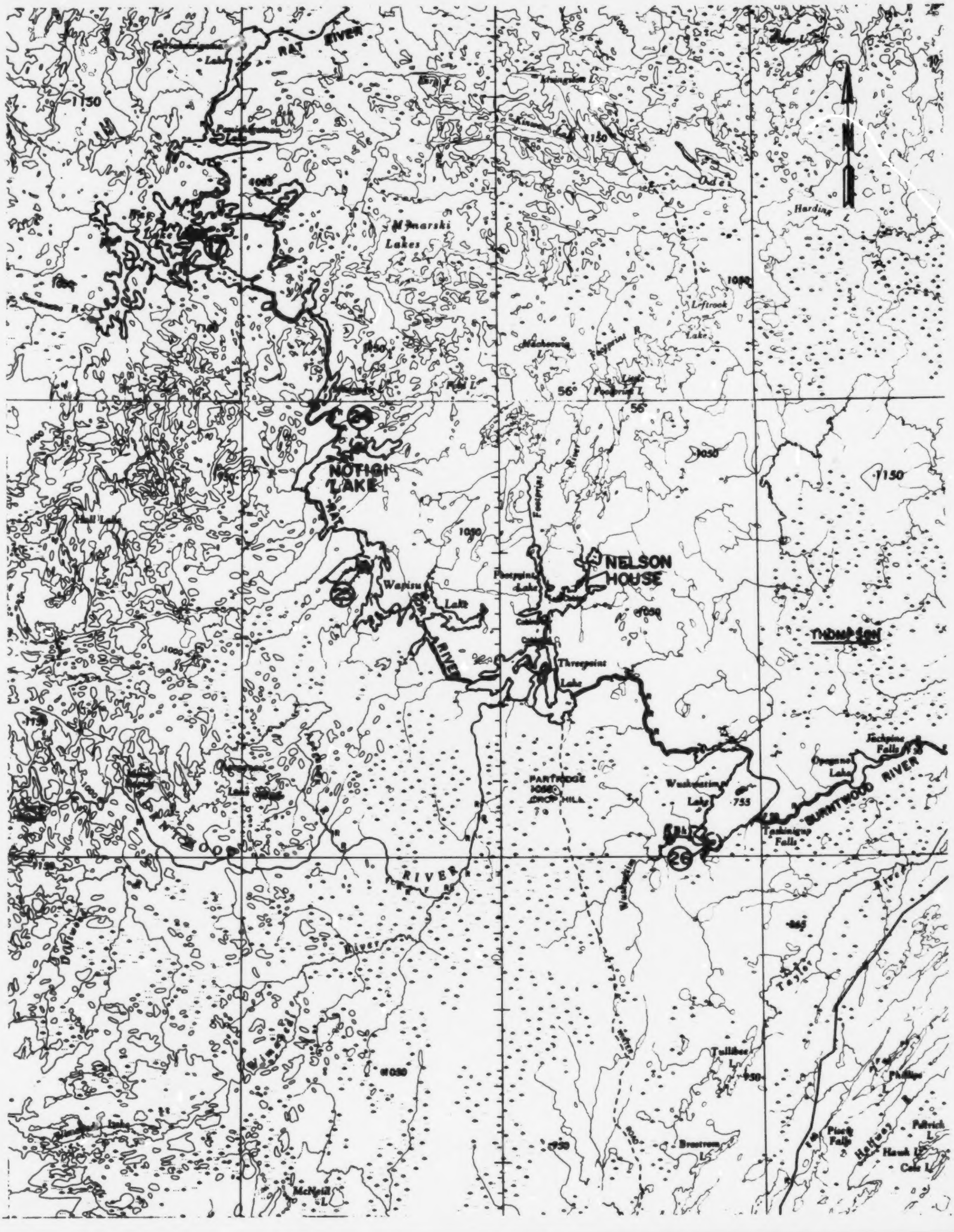
CANADA-MANITOBA

LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

CAMP LOCATIONS

INDEX MAP NO. 1

PREPARED R.Z.
DRAWN P.G.
CHECKED
SUBMITTED
DATE
APPROVED
DATE
SCALE
DATE SEP. 72
SHEET OF
FIGURE NO. 1


RAT RIVER
Lake
Burj L.
Livingston L.
Kinosew Lake
1150
Odei
Harding L
R.
Mynarski Lakes
1100
1050
1000
Pill L.
Mackeovie L
Footprint R.
Leftrook Lake
Little Footprint L.
56°
56°
24
NOTIGI LAKE
River
Footprint
1050
1150
Hall Lake
950
NELSON HOUSE
Footprint Lake
Wapisu
22
Lake
RIVER
Threepoint Lake
THOMPSON
1000
PARTRIDGE
1050
CROP HILL
Washwatim Lake
755
Jackpine Falls
Opegano Lake
BURNTWOOD RIVER
Taskinigup Falls
26
BURNTWOOD
RIVER
River
1100
Duffus
1050
Lake
McNeill L
Taylor
River
Tullibee L.
950
950
Brostrom L
Pisew Falls
Phillips L.
Halfway
Pafrick L.
Hawk L.
Cole L.

PREPARED R.Z.	DRAWN P.G. CHECKED	SUBMITTED DATE	APPROVED DATE	SCALE	DATE SEP. 72	SHEET OF	FIGURE NO. 2

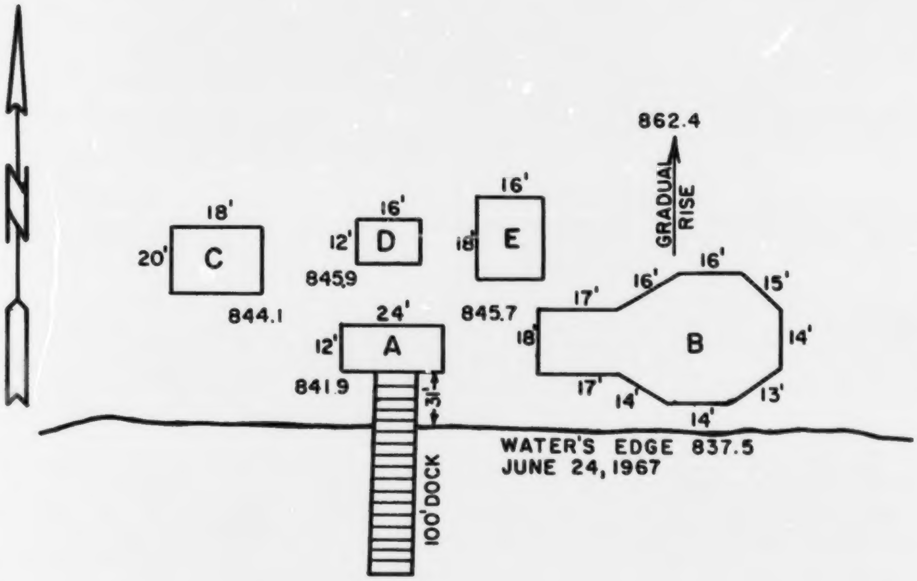
PROVINCE OF MANITOBA

DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG,CHURCHILL AND NELSON RIVERS STUDY BOARD

CAMP LOCATIONS
INDEX MAP NO.2


862.4
GRADUAL RISE
18'
16'
16'
C
20'
12'
D
18'
E
845.9
844.1
24'
845.7
17'
16'
16'
15'
12'
A
18'
B
14'
841.9
31'
17'
14'
14'
13'
100' DOCK
WATER'S EDGE 837.5
JUNE 24, 1967

'NORTH END FISH CAMP'
SOUTHERN INDIAN LAKE

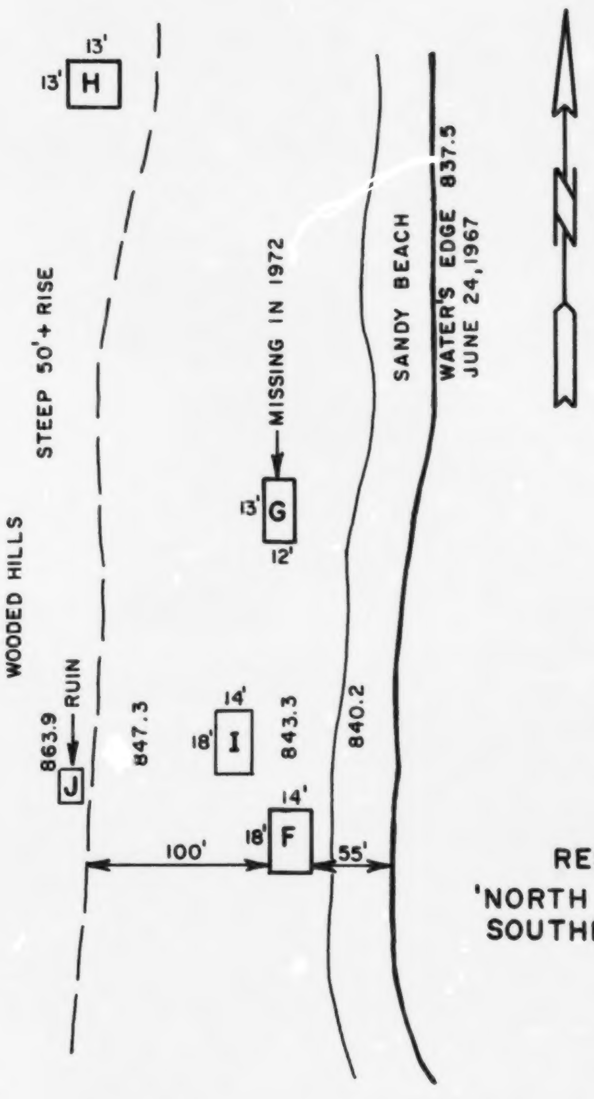
98° 32' W
57° 31' N

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SKETCH
OF
CAMP NO. 1

PREPARED R. Z.	DRAWN P.G. CHECKED	SUBMITTED DATE	APPROVED DATE	SCALE N.T.S.	DATE SEP. 72	SHEET OF	FIGURE NO. 3


13'
13'
H
STEEP 50'+ RISE
WOODED HILLS
MISSING IN 1972
13'
G
12'
SANDY BEACH
WATER'S EDGE 837.5
JUNE 24, 1967
RUIN
863.9
J
847.3
14'
18'
I
843.3
840.2
14'
18'
F
100'
55'

RESIDENCE FOR
'NORTH END FISH CAMP'
SOUTHERN INDIAN LAKE

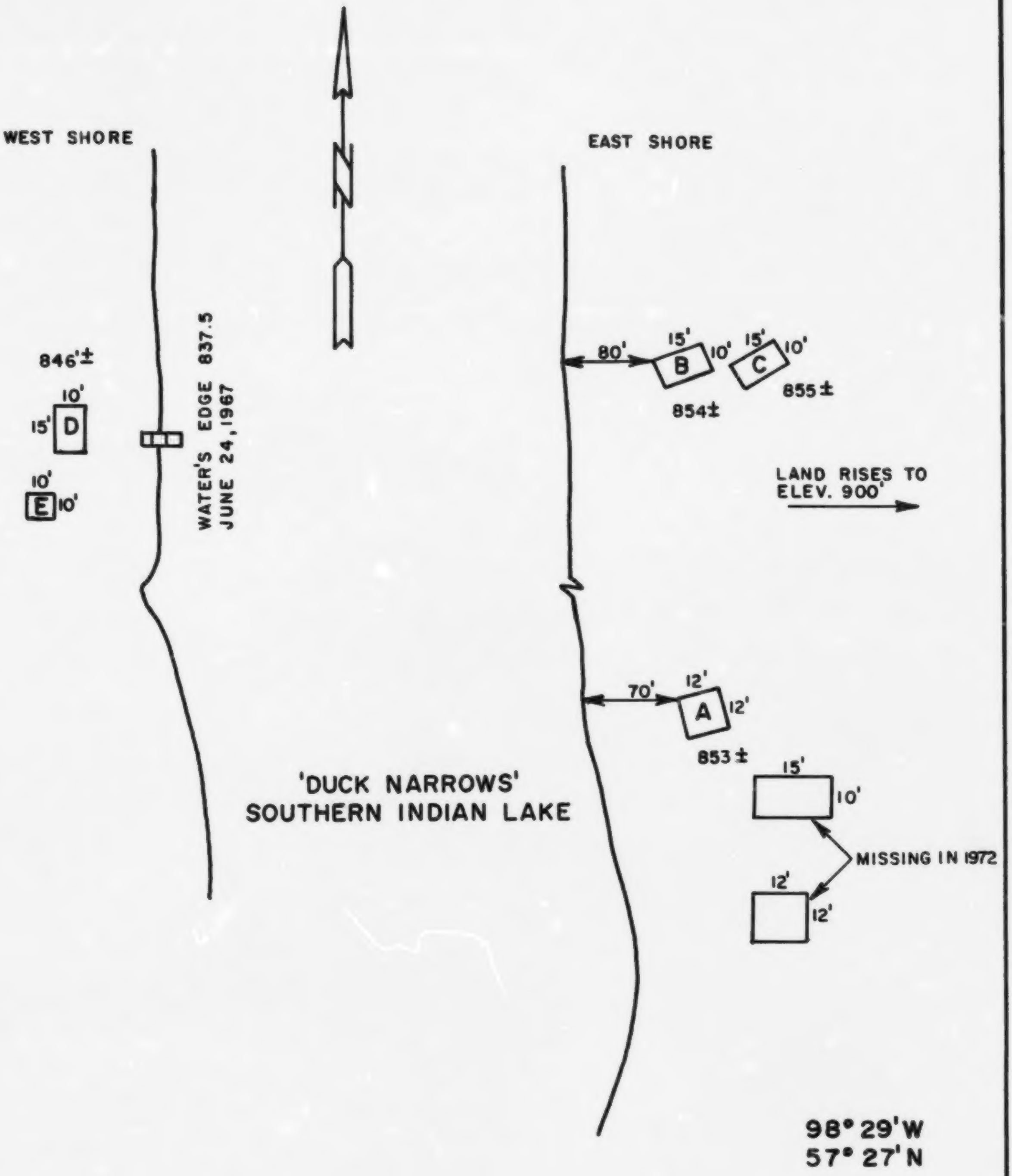
PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

PREPARED	DRAWN	SUBMITTED	APPROVED
R. Z.	P.G.		
	CHECKED	DATE	DATE

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

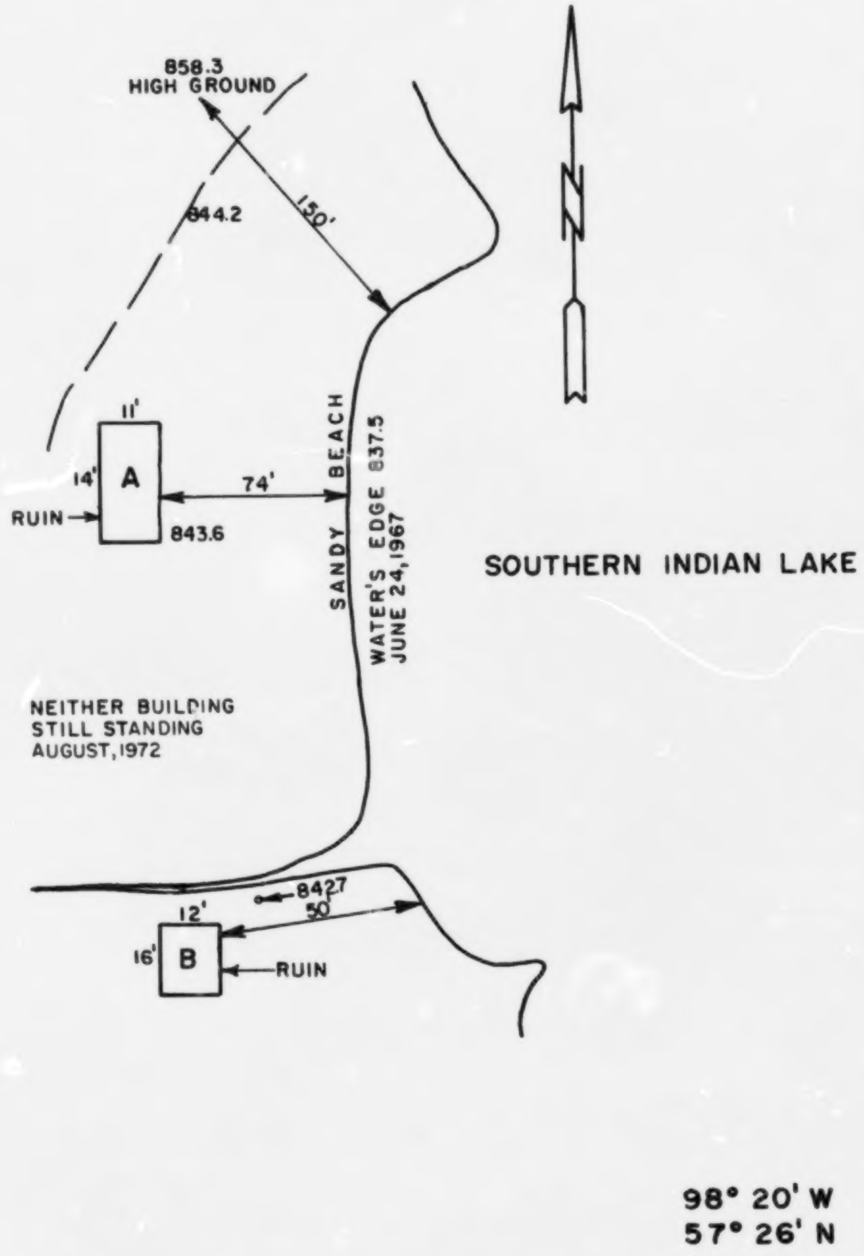
SKETCH
OF
CAMP NO. 1B

SCALE	DATE	SHEET OF	FIGURE NO.
N.T.S.	SEP. 72		4


WEST SHORE
EAST SHORE
846'±
10'
15'
D
10'
E
10'
WATER'S EDGE 837.5
JUNE 24, 1967
80'
15'
B
10'
15'
C
10'
854±
855±
LAND RISES TO
ELEV. 900'
70'
12'
A
12'
853±
15'
10'
MISSING IN 1972
12'
12'
'DUCK NARROWS'
SOUTHERN INDIAN LAKE
98° 29'W
57° 27'N

PROVINCE OF MANITOBA DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT WATER RESOURCES BRANCH	CANADA-MANITOBA LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD SKETCH OF CAMP NO. 2

PREPARED	DRAWN	SUBMITTED	APPROVED	SCALE	DATE	SHEET	OF	FIGURE NO.
R. Z.	P.G.			N.T.S.	SEP. 72			5
	CHECKED	DATE	DATE					

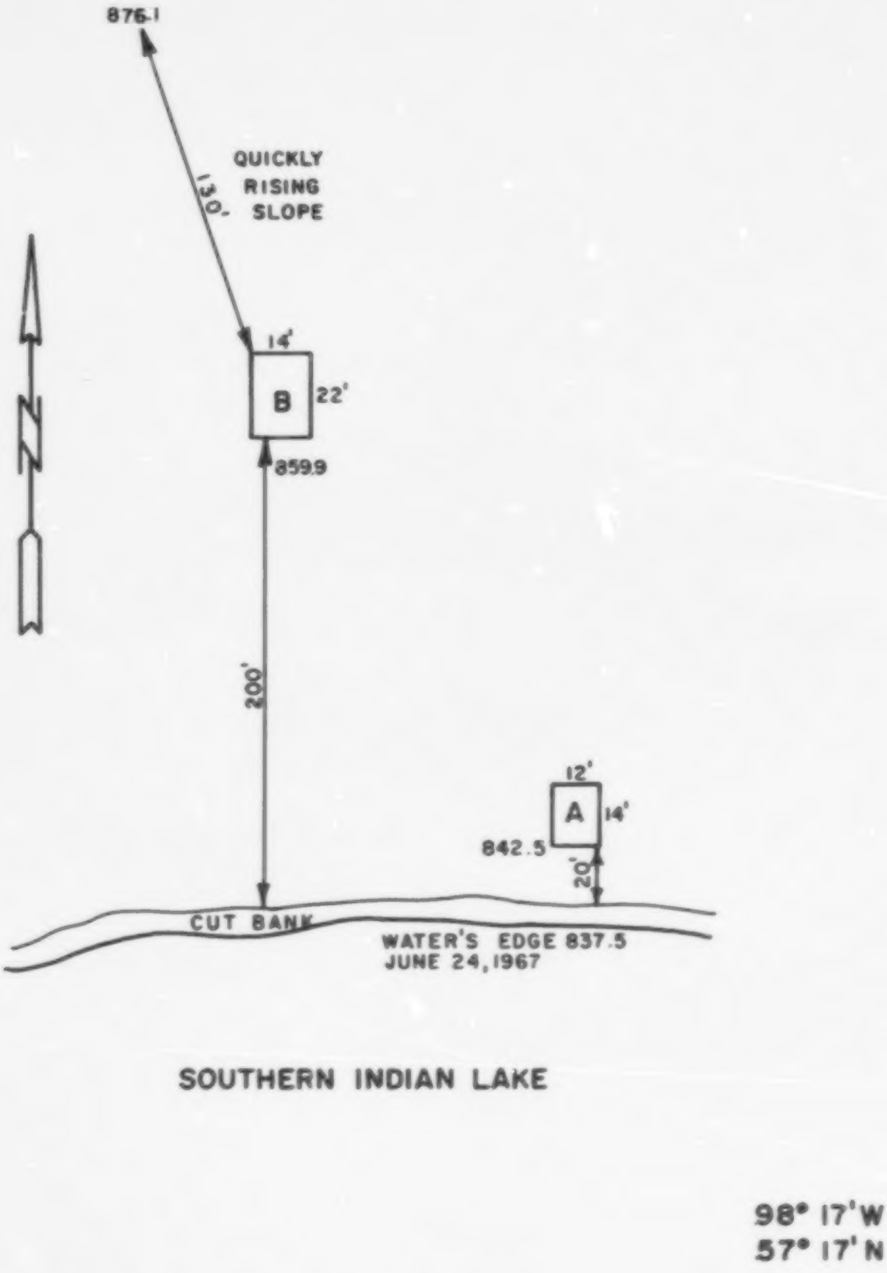

858.3
HIGH GROUND
150'
844.2
11'
14'
A
74'
RUIN
843.6
SANDY BEACH
WATER'S EDGE 837.5
JUNE 24, 1967
SOUTHERN INDIAN LAKE
N
NEITHER BUILDING
STILL STANDING
AUGUST, 1972
842.7
50'
12'
16'
B
RUIN
98° 20' W
57° 26' N

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SKETCH OF CAMP NO. 3

PREPARED	DRAWN	SUBMITTED	APPROVED	SCALE	DATE	SHEET	FIGURE NO.
R. Z.	P.G.			N.T.S.	SEP. 72	OF	6
	CHECKED	DATE	DATE				

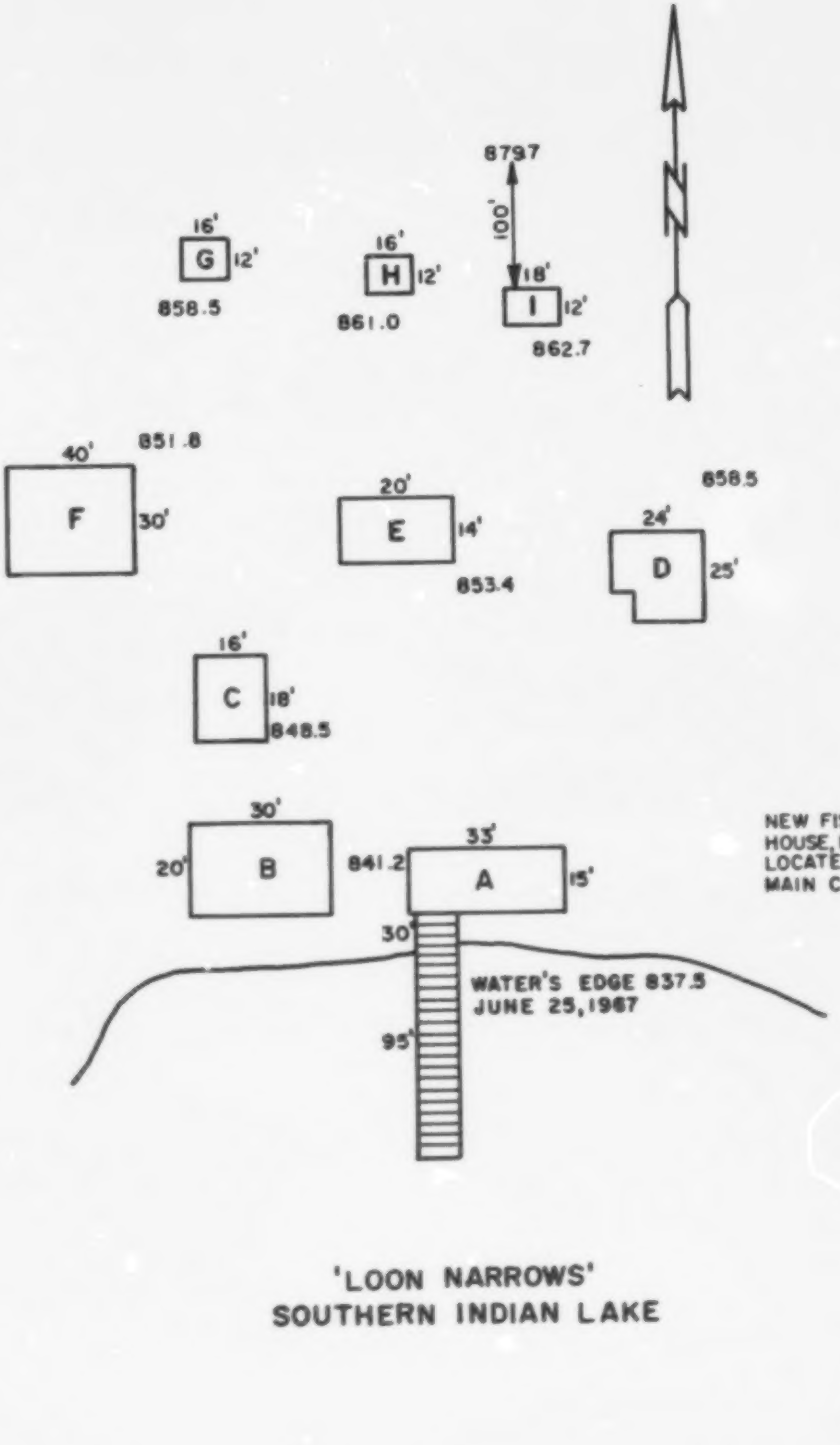

876.1
130'
QUICKLY
RISING
SLOPE
N
14'
B
22'
859.9
200'
12'
A
14'
842.5
20'
CUT BANK
WATER'S EDGE 837.5
JUNE 24, 1967
SOUTHERN INDIAN LAKE
98° 17' W
57° 17' N

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA–MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SKETCH
OF
CAMP NO. 4

PREPARED R. Z.
DRAWN P.G.
CHECKED
SUBMITTED
DATE
APPROVED
DATE
SCALE N.T.S.
DATE SEP. 72
SHEET OF
FIGURE NO. 7


879.7
100'
16'
G
12'
858.5
16'
H
12'
861.0
18'
I
12'
862.7
40'
851.8
F
30'
20'
E
14'
853.4
858.5
24'
D
25'
16'
C
18'
848.5
30'
20'
B
841.2
33'
A
15'
30'
WATER'S EDGE 837.5
JUNE 25, 1967
95'

NEW FISH HOUSE AND ICE HOUSE, BUILDINGS J AND K, LOCATED TO EAST OF MAIN CAMP.

'LOON NARROWS'
SOUTHERN INDIAN LAKE

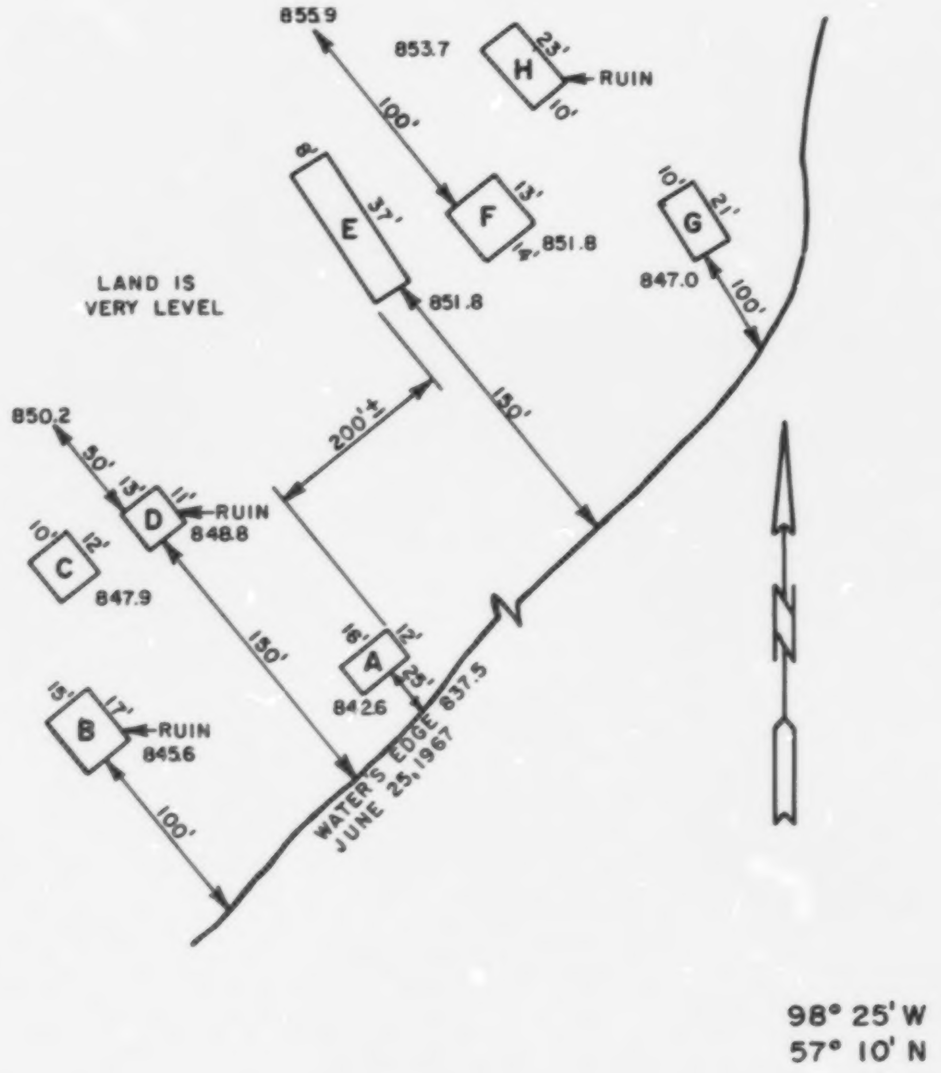
93° 32' W
57° 16' N

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SKETCH
OF
CAMP NO. 5

PREPARED	DRAWN	SUBMITTED	APPROVED	SCALE	DATE	SHEET OF	FIGURE NO.
R. Z.	P.G.			N.T.S.	SEP. 72		8
	CHECKED	DATE	DATE				


855.9
853.7
H
23'
10'
RUIN
100'
E
8'
37'
F
13'
12'
851.8
G
10'
21'
847.0
100'
851.8
LAND IS
VERY LEVEL
200'±
150'
850.2
50'
D
13'
11'
RUIN
848.8
C
10'
12'
847.9
150'
A
16'
8'
12'
25'
842.6
B
15'
17'
RUIN
845.6
100'
WATER'S EDGE 837.5
JUNE 25, 1967
N
98° 25' W
57° 10' N

PROVINCE OF MANITOBA

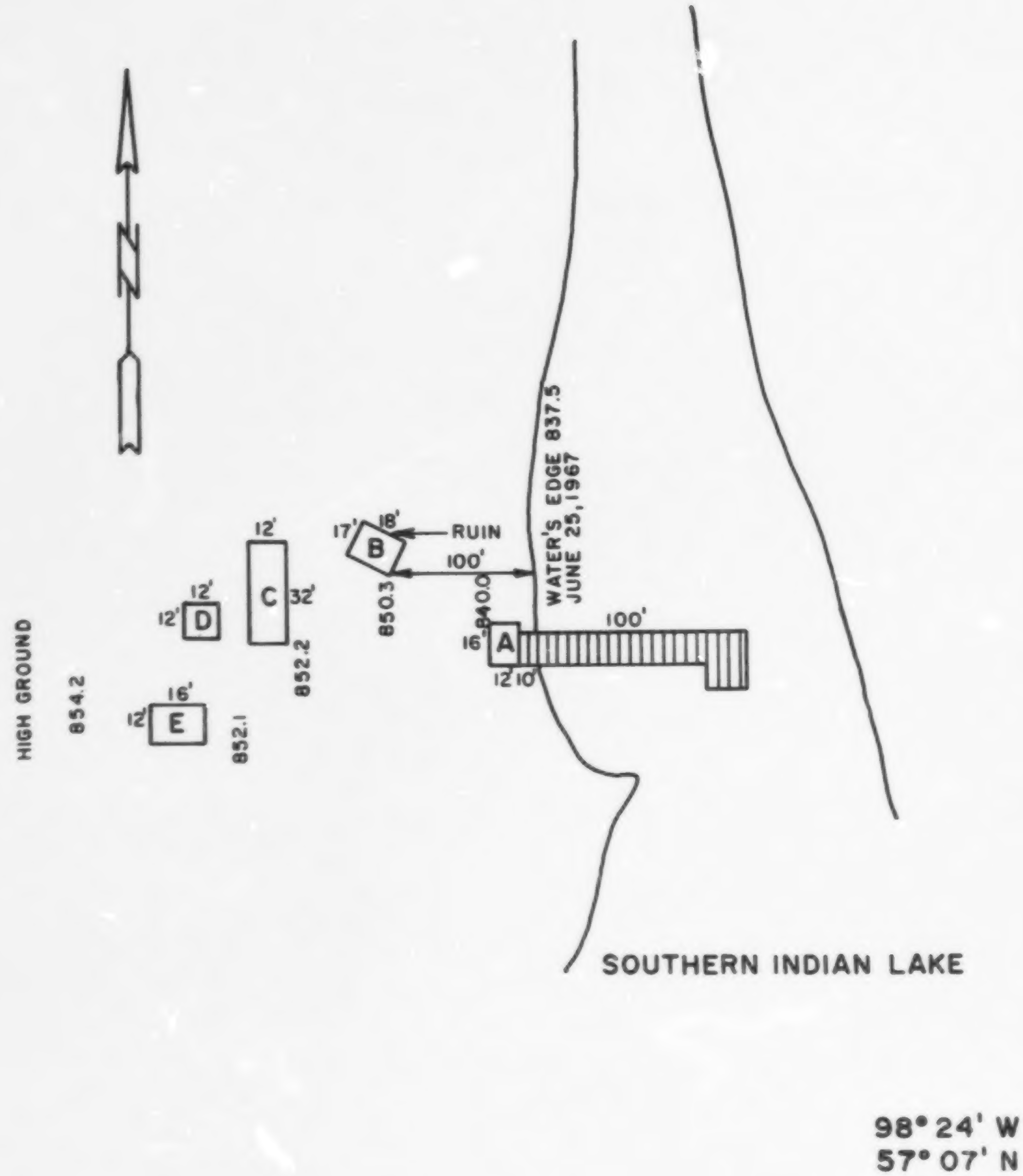
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SKETCH
OF
CAMP NO. 6

PREPARED	DRAWN P.G.	SUBMITTED	APPROVED	SCALE N.T.S.	DATE SEP. 72	SHEET OF	FIGURE NO. 9
R. Z.	CHECKED	DATE	DATE				


RUIN
17'
18'
B
100'
WATER'S EDGE 837.5
JUNE 25,1967
12'
C
32'
12'
12'
D
850.3
840.0
16'
A
12
10'
100'
852.2
HIGH GROUND
854.2
16'
12'
E
852.1
SOUTHERN INDIAN LAKE
98° 24' W
57° 07' N

PROVINCE OF MANITOBA

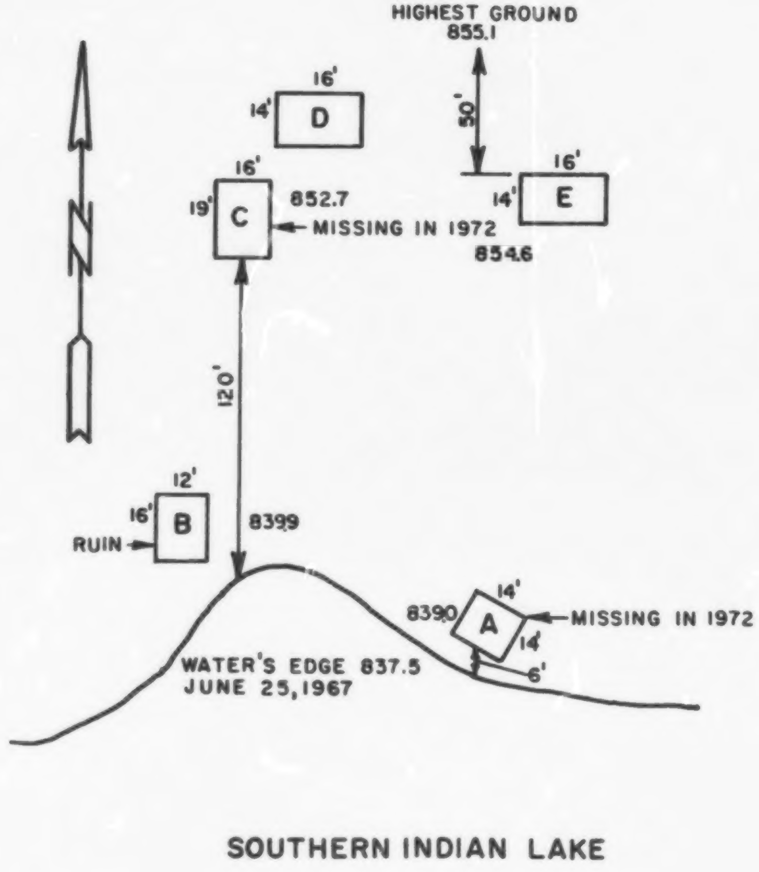
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SKETCH OF CAMP NO. 7

PREPARED R. Z.	DRAWN P.G. CHECKED	SUBMITTED DATE	APPROVED DATE	SCALE N.T.S.	DATE SEP. 72	SHEET OF	FIGURE NO. 10


HIGHEST GROUND
855.1
50'
16'
14'
D
16'
19'
C
852.7
MISSING IN 1972
16'
14'
E
854.6
N
120'
12'
16'
B
RUIN
839.9
14'
839.0
A
14'
MISSING IN 1972
6'
WATER'S EDGE 837.5
JUNE 25, 1967
SOUTHERN INDIAN LAKE

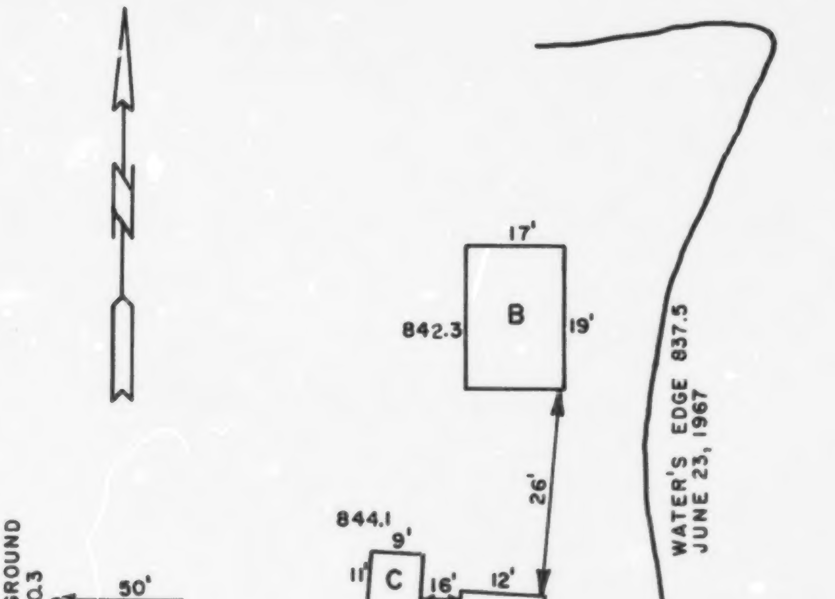
98° 35' W
57° 04' N

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SKETCH OF CAMP NO. 8

PREPARED	DRAWN	SUBMITTED	APPROVED	SCALE	DATE	SHEET OF	FIGURE NO.
R. Z.	P.G.			N.T.S.	SEP. 72		11
	CHECKED	DATE	DATE				

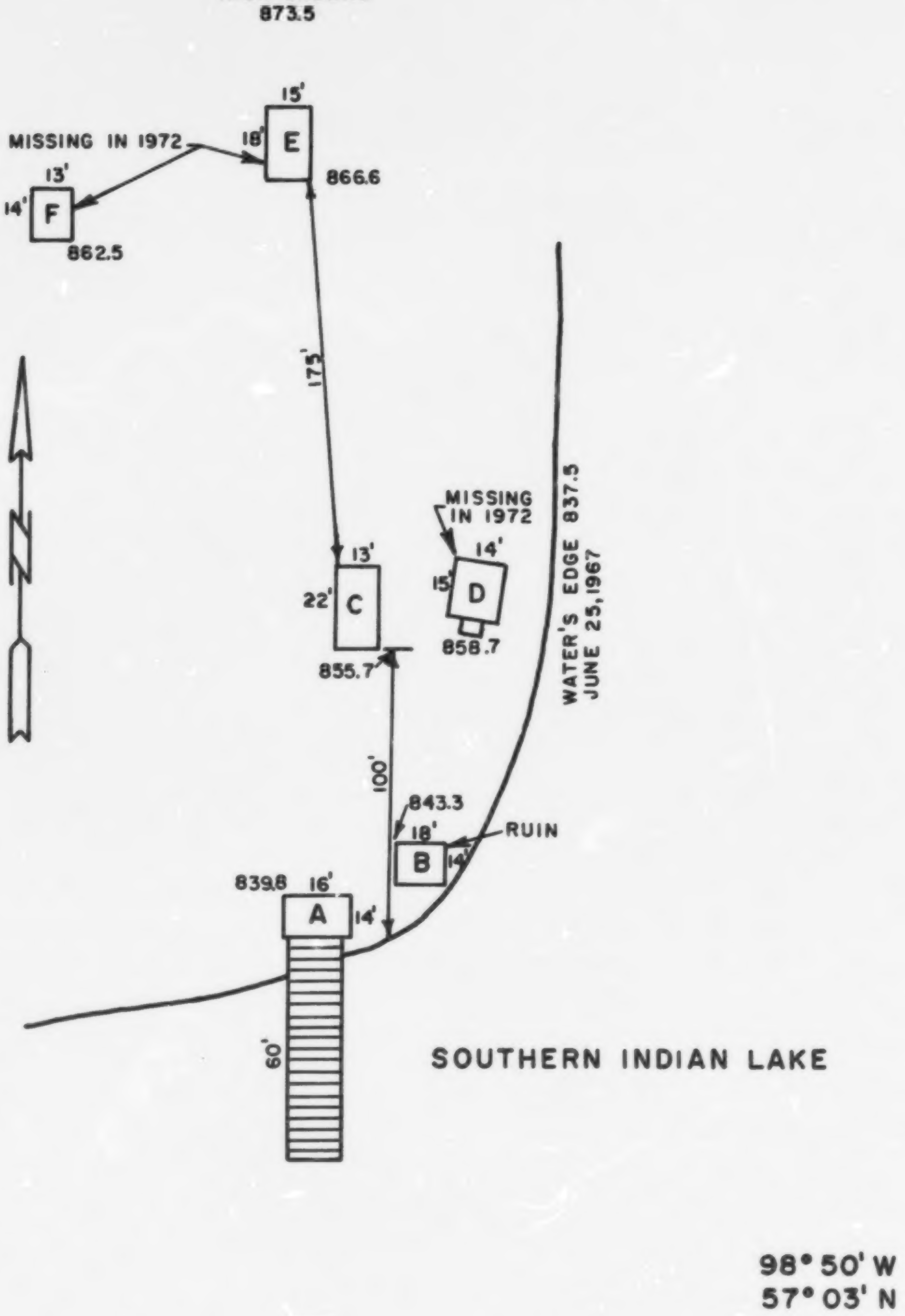

17'
B
842.3
19'
WATER'S EDGE 837.5
JUNE 23, 1967
26'
844.1
9'
C
11'
16'
12'
HIGH GROUND
850.3
50'
14'
A
24'
27'
841.3
846.0

'RED ROCK FISH CAMP'
SOUTHERN INDIAN LAKE

99° 13' W
57° 11' N

PROVINCE OF MANITOBA DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT WATER RESOURCES BRANCH	CANADA-MANITOBA LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD SKETCH OF CAMP NO. 9

PREPARED	DRAWN	SUBMITTED	APPROVED	SCALE	DATE	SHEET OF	FIGURE NO.
R. Z.	P.G.			N.T.S.	SEP. 72		12
	CHECKED	DATE	DATE				


HIGH GROUND
873.5
15'
MISSING IN 1972
18'
E
866.6
13'
14'
F
862.5
175'
MISSING
IN 1972
14'
15'
D
858.7
13'
22'
C
855.7
WATER'S EDGE 837.5
JUNE 25, 1967
100'
843.3
18'
RUIN
B
14'
839.8
16'
A
14'
60'
SOUTHERN INDIAN LAKE
98° 50' W
57° 03' N

PROVINCE OF MANITOBA

DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

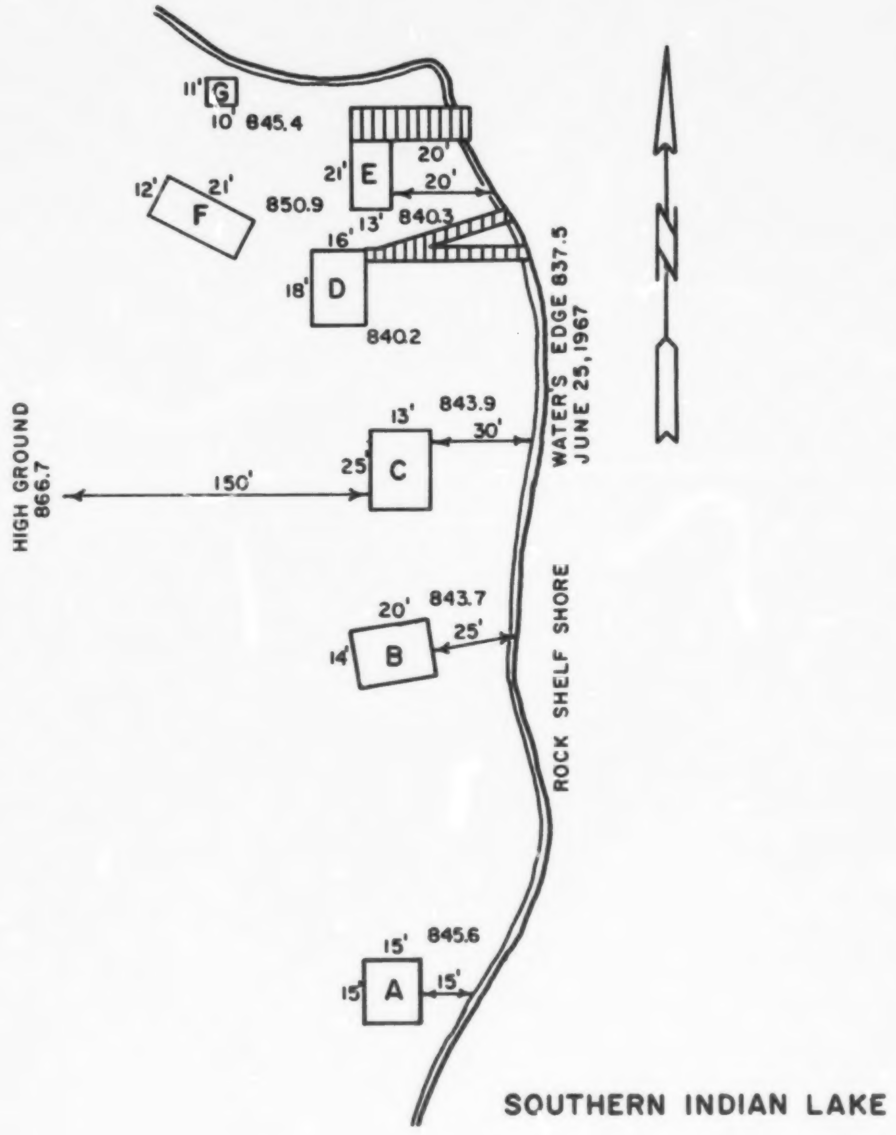
WATER RESOURCES BRANCH

PREPARED	DRAWN	SUBMITTED	APPROVED
R. Z.	P.G.		
	CHECKED	DATE	DATE

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SKETCH
OF
CAMP NO. 10

SCALE	DATE	SHEET	OF	FIGURE NO.
N.T.S.	SEP. 72			13


11'
G
10' 845.4
20'
21'
E
20'
12'
21'
F
850.9
13' 840.3
16'
18'
D
840.2
WATER'S EDGE 837.5
JUNE 25, 1967
N
13' 843.9
30'
HIGH GROUND
866.7
150'
25'
C
20' 843.7
25'
14'
B
ROCK SHELF SHORE
15' 845.6
15'
A
15'
SOUTHERN INDIAN LAKE

'CO-OP CAMP NO. NINE'

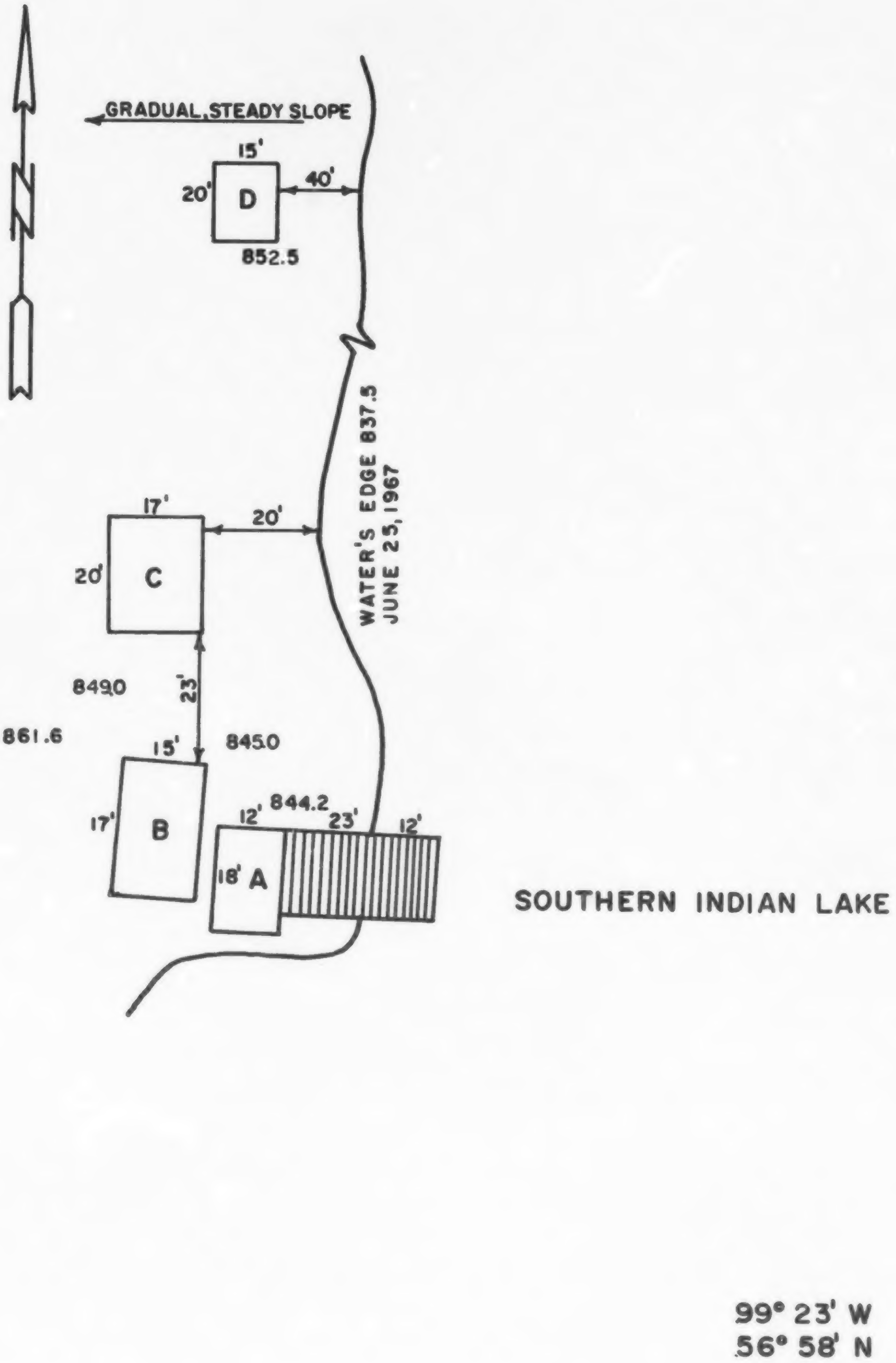
98°41' W
57°00' N

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SKETCH
OF
CAMP NO. 11

PREPARED	DRAWN	SUBMITTED	APPROVED	SCALE	DATE	SHEET OF	FIGURE NO.
R. Z.	P.G.			N.T.S.	SEP. 72		14
	CHECKED	DATE	DATE				


GRADUAL, STEADY SLOPE
15'
20'
D
40'
852.5
WATER'S EDGE 837.5
JUNE 25, 1967
17'
20'
20'
C
849.0
23'
861.6
15'
845.0
17'
B
12'
844.2
23'
12'
18'
A
SOUTHERN INDIAN LAKE
99° 23' W
56° 58' N

PROVINCE OF MANITOBA

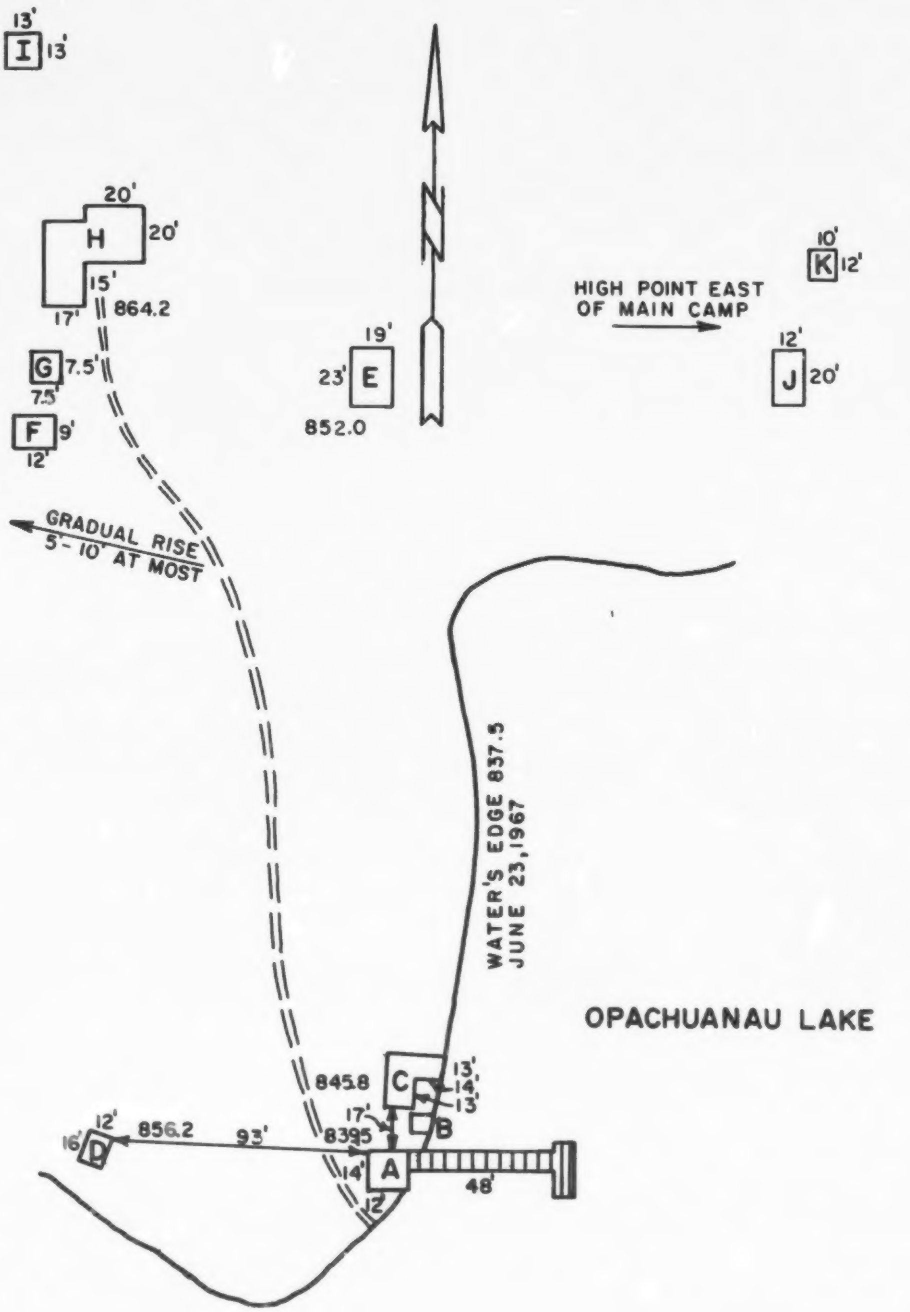
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SKETCH
OF
CAMP NO. 12

PREPARED	DRAWN	SUBMITTED	APPROVED	SCALE	DATE	SHEET OF	FIGURE NO.
R. Z.	P.G.			N.T.S.	SEP. 72		15
	CHECKED	DATE	DATE				


13'
I
13'
20'
H
20'
15'
17'
864.2
G
7.5'
7.5'
F
9'
12'
19'
23'
E
852.0
HIGH POINT EAST OF MAIN CAMP
10'
K
12'
12'
J
20'
GRADUAL RISE 5'- 10' AT MOST
WATER'S EDGE 837.5 JUNE 23,1967
OPACHUANAU LAKE
C
845.8
13'
14'
13'
B
17'
839.5
12'
16'
D
856.2
93'
A
14'
12'
48'

'OWEN ASHLEY RESIDENCE AND FISH CAMP'

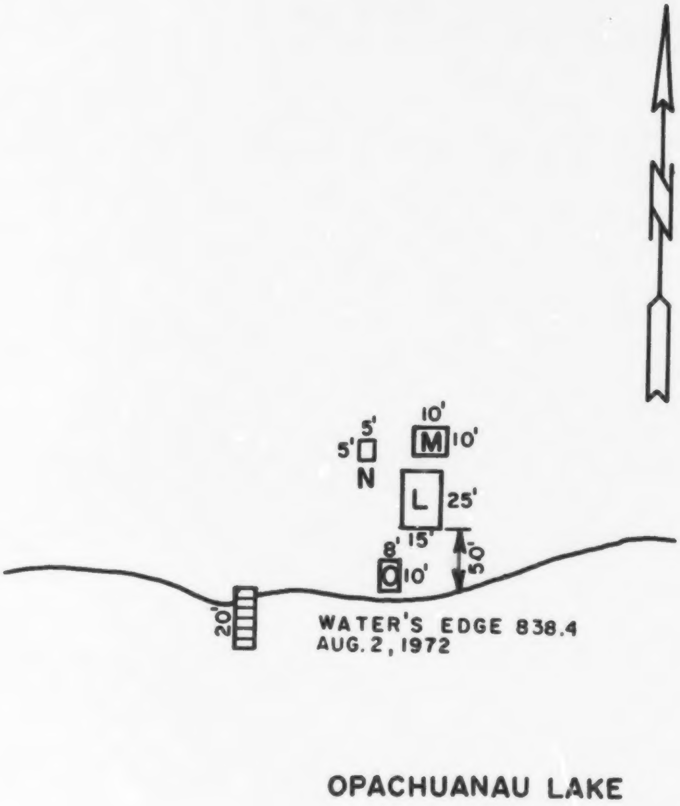
99° 44' W
56° 47' N

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SKETCH OF CAMP NO. 13

PREPARED	DRAWN	SUBMITTED	APPROVED	SCALE	DATE	SHEET OF	FIGURE NO.
R. Z.	P.G.		Mudry	N.T.S.	SEP. 72		16
	CHECKED	DATE	DATE				


5'
5'
N
10'
M
10'
L
25'
15'
8'
O
10'
50'
20'
WATER'S EDGE 838.4
AUG. 2, 1972
OPACHUANAU LAKE

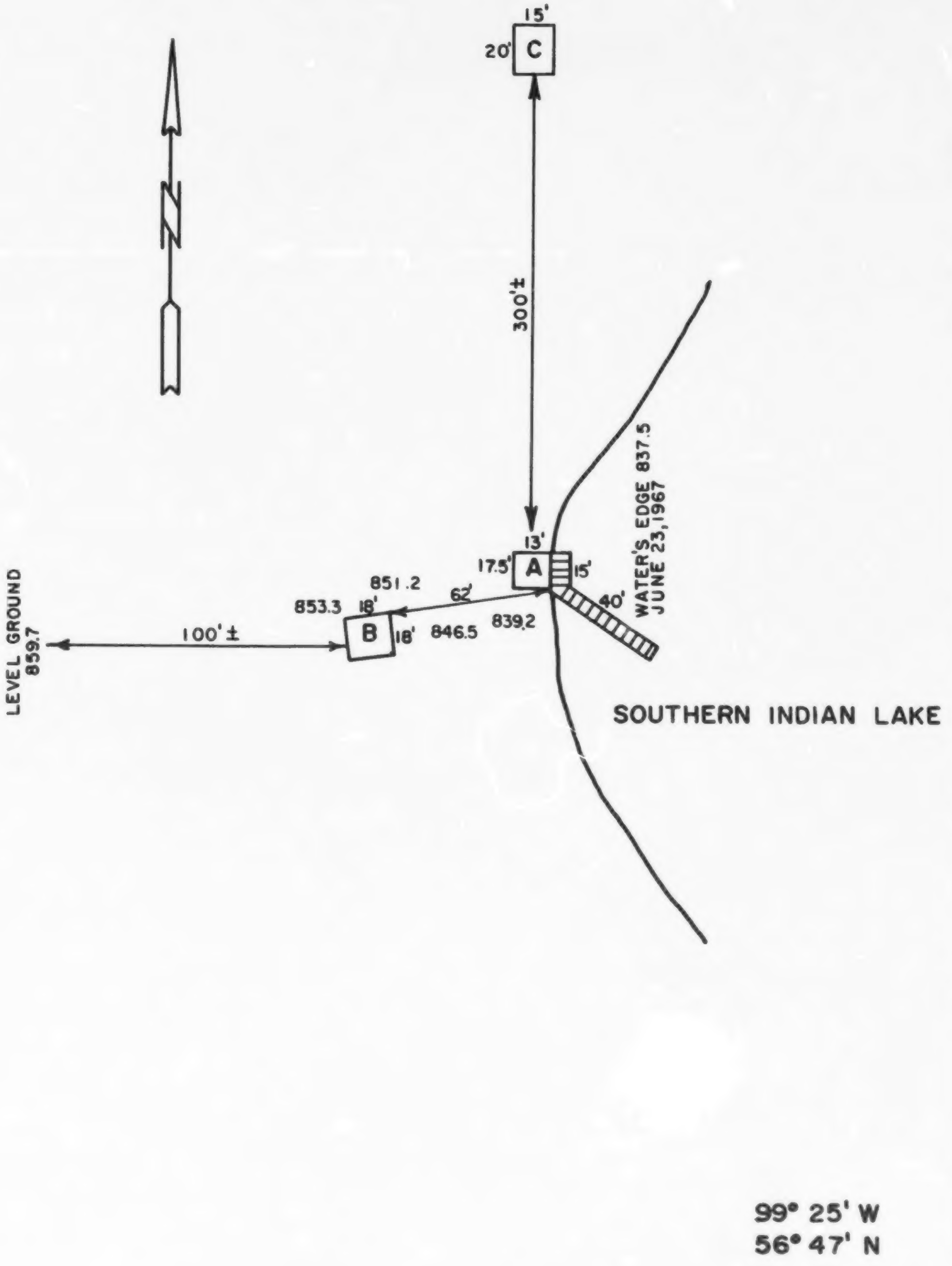
PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

PREPARED	DRAWN P.G.	SUBMITTED	APPROVED
R. Z.	CHECKED	DATE	DATE

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SKETCH
OF
CAMP NO.13B

SCALE	DATE	SHEET OF	FIGURE NO.
N.T.S.	SEP. 72		17


15'
20'
C
300'±
13'
17.5'
A
15'
40'
WATER'S EDGE 837.5
JUNE 23, 1967
851.2
62'
853.3
18'
B
18'
846.5
839.2
100'±
LEVEL GROUND
859.7
SOUTHERN INDIAN LAKE
99° 25' W
56° 47' N

PROVINCE OF MANITOBA

DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

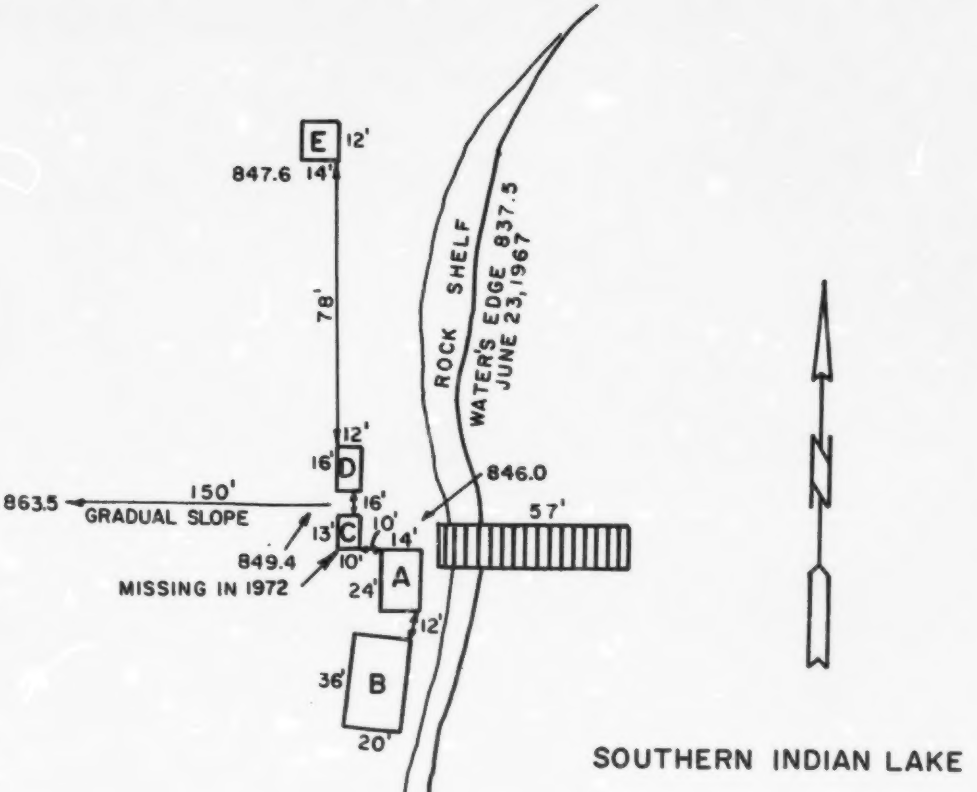
WATER RESOURCES BRANCH

PREPARED	DRAWN	SUBMITTED	APPROVED
R. Z.	P.G.		
	CHECKED	DATE	DATE

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SKETCH OF CAMP NO. 14

SCALE	DATE	SHEET	OF	FIGURE NO.
N.T.S.	SEP. 72			18


E
12'
847.6
14'
78'
12'
16'
D
150'
863.5
GRADUAL SLOPE
16'
13'
C
10'
14'
849.4
10'
MISSING IN 1972
A
24'
12'
846.0
57'
B
36'
20'
ROCK SHELF
WATER'S EDGE 837.5
JUNE 23,1967
N
SOUTHERN INDIAN LAKE

'CO-OP CAMP NO. THREE'

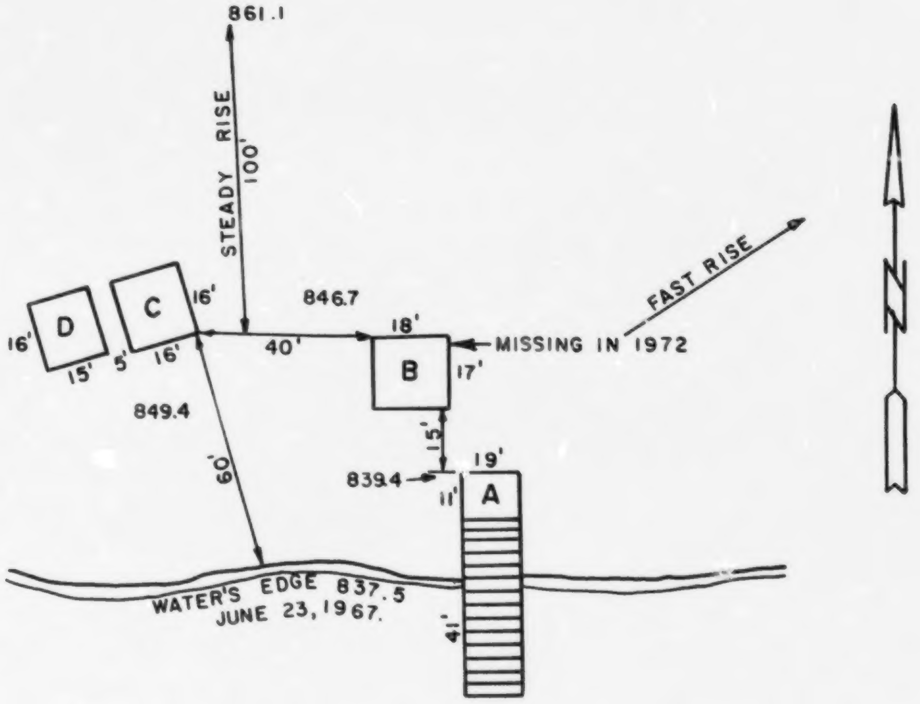
96° 06' W
56° 53' N

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SKETCH
OF
CAMP NO.15

PREPARED R. Z.	DRAWN P.G.	SUBMITTED	APPROVED	SCALE N.T.S.	DATE SEP. 72	SHEET OF	FIGURE NO. 19
	CHECKED	DATE	DATE				


861.1
STEADY RISE
100'
846.7
16'
D
C
16'
15'
5'
16'
40'
18'
B
17'
MISSING IN 1972
FAST RISE
849.4
60'
15'
19'
839.4
11'
A
WATER'S EDGE 837.5
JUNE 23, 1967.
41'

'BILL ANDERSON'S FISH CAMP'
SOUTHERN INDIAN LAKE

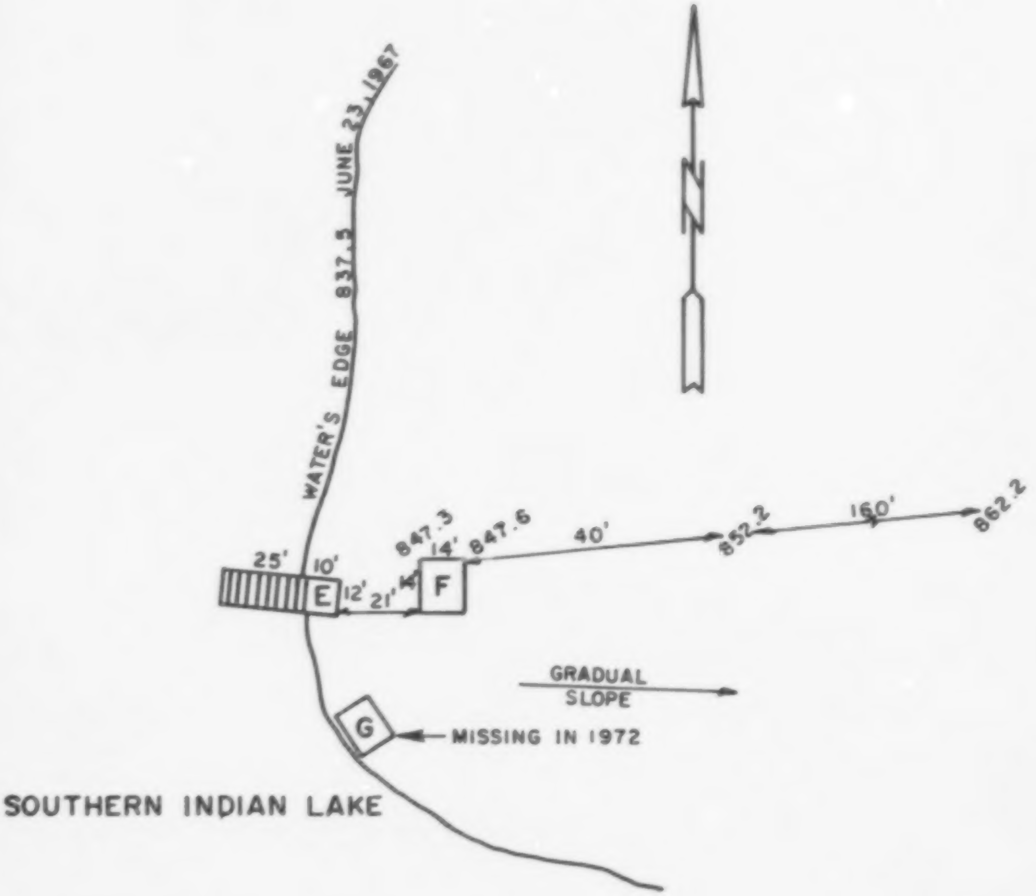
98° 49' W
56° 41' N

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SKETCH
OF
CAMP NO. 16

PREPARED R. Z.	DRAWN P.G.	SUBMITTED	APPROVED	SCALE N.T.S.	DATE SEP. 72	SHEET OF	FIGURE NO. 20
	CHECKED	DATE	DATE				

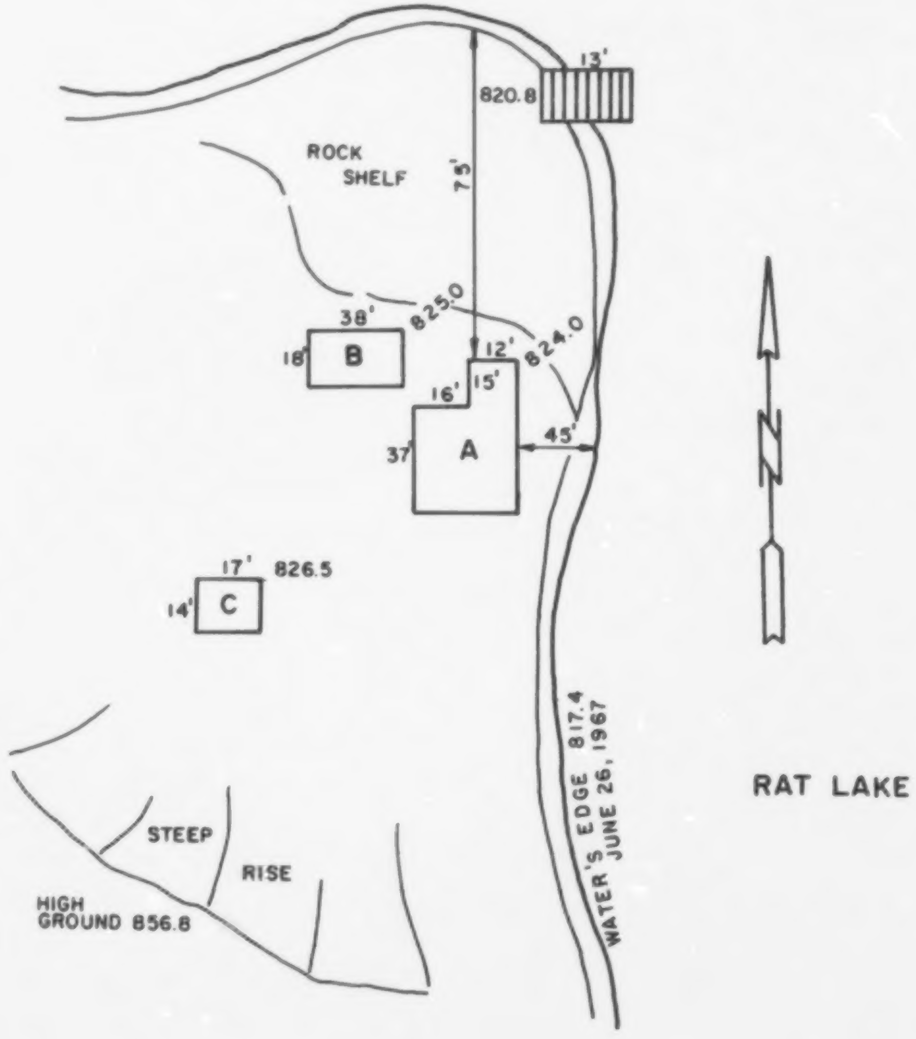

WATER'S EDGE 837.3 JUNE 23, 1967
25'
10'
E
12'
21'
14'
847.3
847.6
F
40'
852.2
160'
862.2
GRADUAL SLOPE
G
MISSING IN 1972
SOUTHERN INDIAN LAKE

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SKETCH OF CAMP NO. 16B

PREPARED R.Z.
DRAWN P.G.
CHECKED
SUBMITTED
DATE
SCALE N.T.S.
DATE SEP. 72
SHEET OF
FIGURE NO. 21


13'
820.8
ROCK
SHELF
75'
825.0
824.0
38'
18'
B
12'
15'
16'
37'
A
45'
17'
826.5
14'
C
STEEP
RISE
HIGH
GROUND 856.8
WATER'S EDGE 817.4
JUNE 26, 1967
RAT LAKE

'RAT LAKE FISH CAMP'

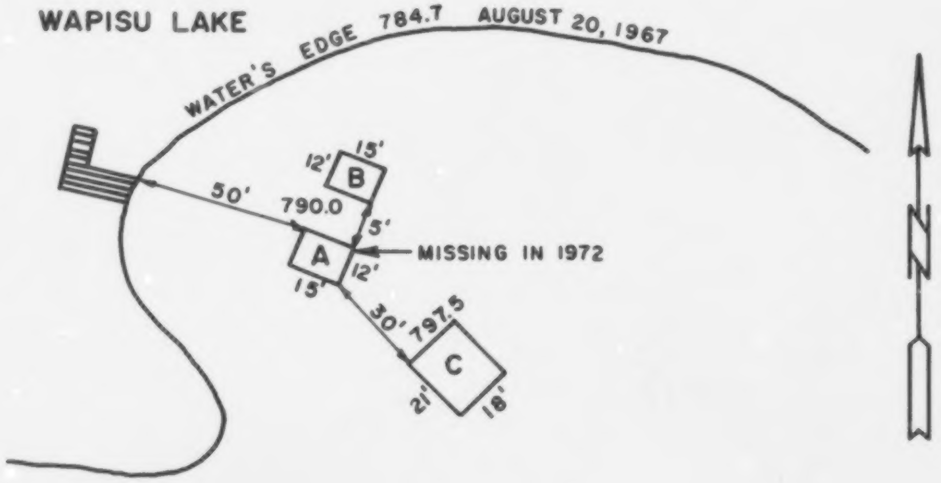
99° 35' W
56° 12' N

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SKETCH
OF
CAMP NO.17

PREPARED R.Z.	DRAWN P.G. CHECKED	SUBMITTED DATE	APPROVED DATE	SCALE N.T.S.	DATE SEP. 72	SHEET OF	FIGURE NO. 22


WAPISU LAKE
WATER'S EDGE 784.7 AUGUST 20, 1967
B
12'
15'
790.0
50'
5'
A
12'
15'
MISSING IN 1972
30'
797.5
C
21'
18'

TWO LOG HOUSES ON POINT OF
LAND SOUTH OF MAIN CAMP:
BUILDINGS D AND E.

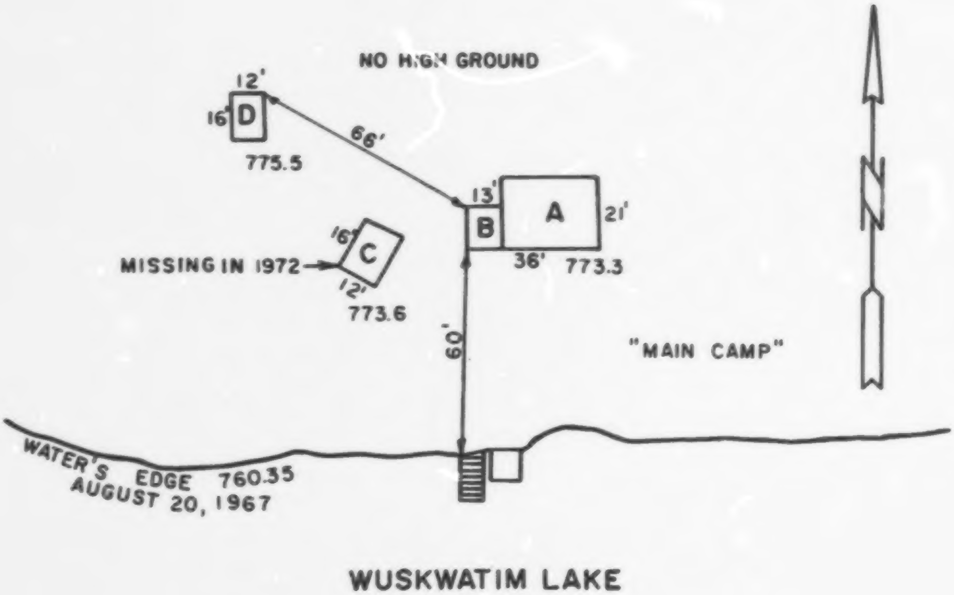
99°15' W
55°48' N

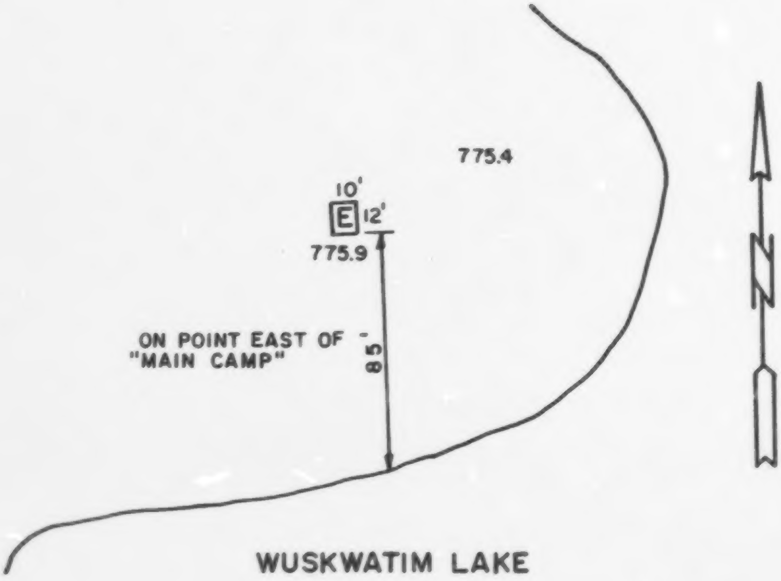
PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SKETCH
OF
CAMP NO.25

PREPARED R. Z.
DRAWN P.G.
CHECKED
SUBMITTED
DATE
APPROVED
DATE
SCALE N.T.S.
DATE SEP. 72
SHEET OF
FIGURE NO. 23


NO HIGH GROUND
12'
16'
D
66'
775.5
13'
A
21'
B
36'
773.3
16'
C
12'
MISSING IN 1972
773.6
60'
"MAIN CAMP"
N
WATER'S EDGE 760.35
AUGUST 20, 1967
WUSKWATIM LAKE


775.4
10'
E
12'
775.9
ON POINT EAST OF
"MAIN CAMP"
85'
N
WUSKWATIM LAKE

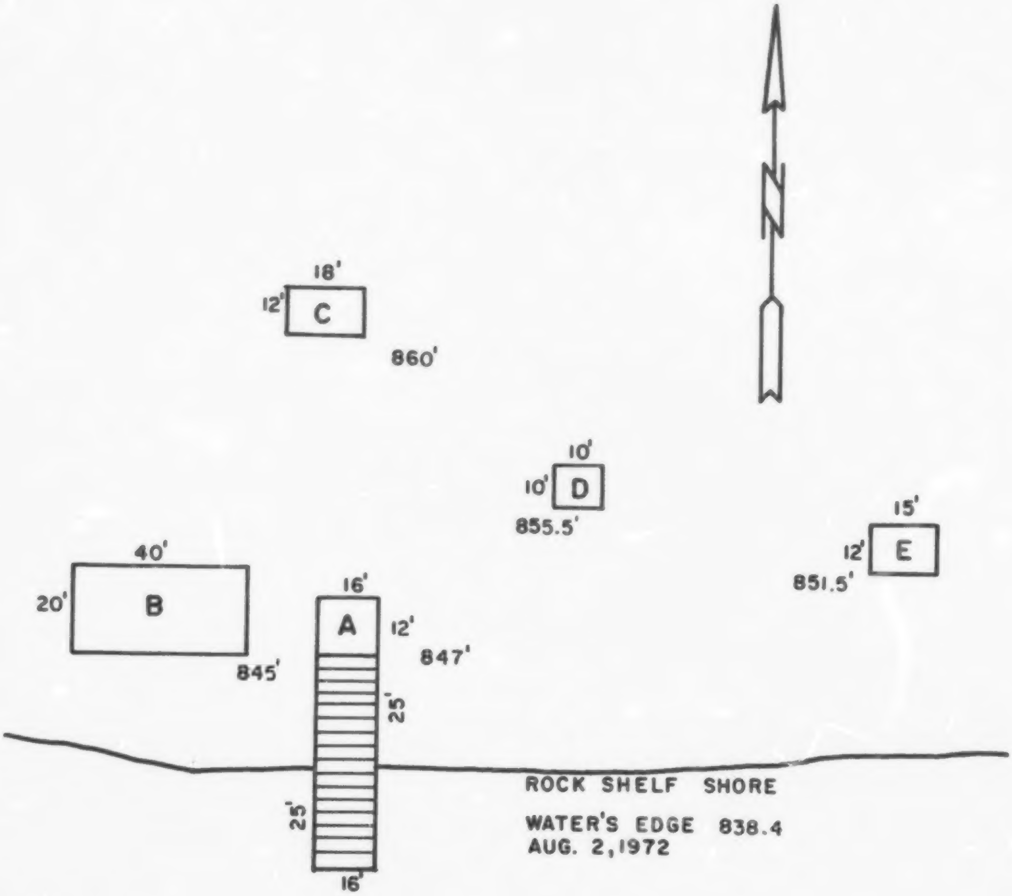
98° 35' W
55° 31' N

PROVINCE OF MANITOBA DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT WATER RESOURCES BRANCH			
PREPARED R. Z.	DRAWN P.G. CHECKED	SUBMITTED DATE	APPROVED DATE

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SKETCH
OF
CAMP NO.26

SCALE N.T.S.	DATE SEP. 72	SHEET OF	FIGURE NO. 24


18'
12'
C
860'
10'
10'
D
855.5'
15'
12'
E
851.5'
40'
20'
B
845'
16'
A
12'
847'
25'
25'
16'
ROCK SHELF SHORE
WATER'S EDGE 838.4
AUG. 2, 1972

'OPACHUANAU FISH CAMP'
OPACHUANAU LAKE

99° 34' W
56° 44' N

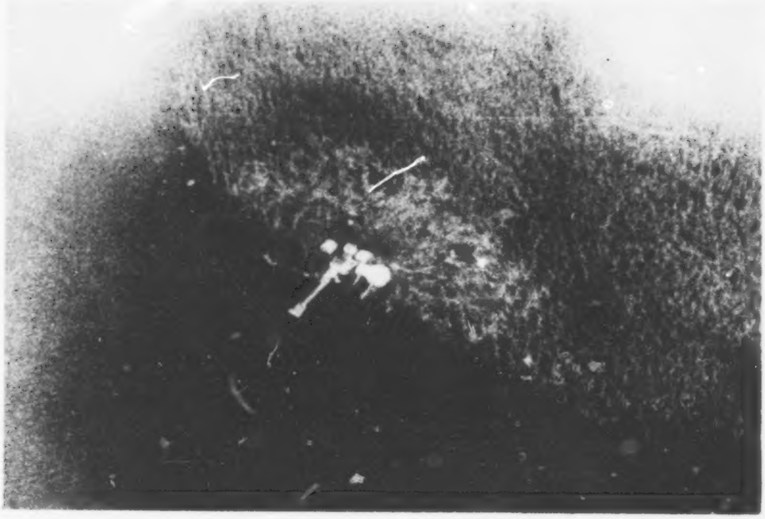
PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

PREPARED R. Z.	DESIGN P.G. CHECKED	SUBMITTED DATE	APPROVED DATE

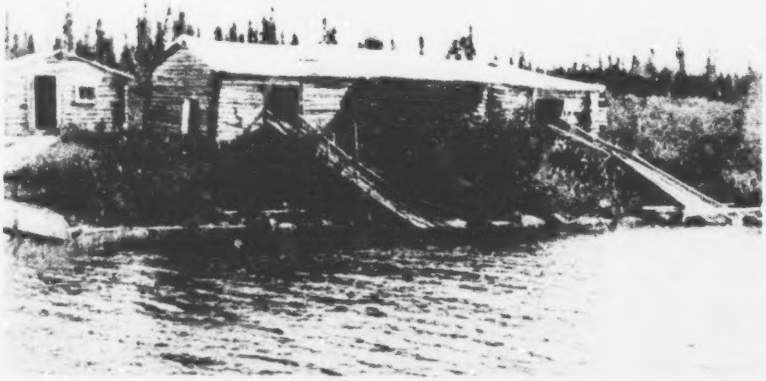
CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SKETCH
OF
CAMP NO. 27

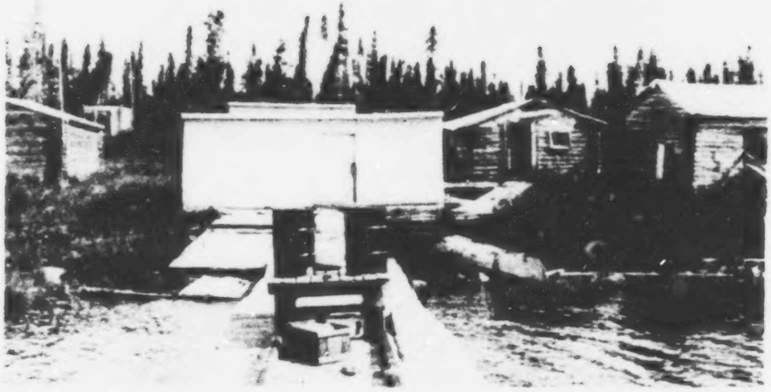
SCALE N.T.S.	DATE SEP. 72	SHEET OF	FIGURE NO. 25



1. Aerial View of Camp No. 1 - "North End Fish Camp"
(1972/161-#2)

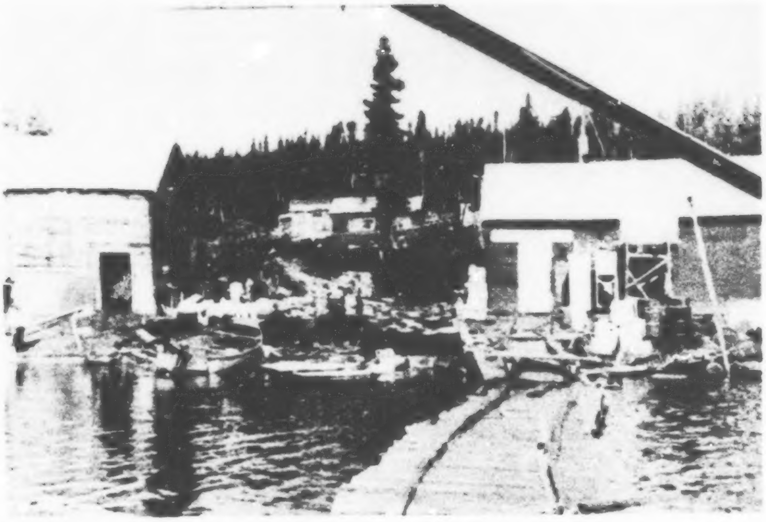


2. Buildings 'E' and 'B' at Camp No. 1
(1972/161-#3)



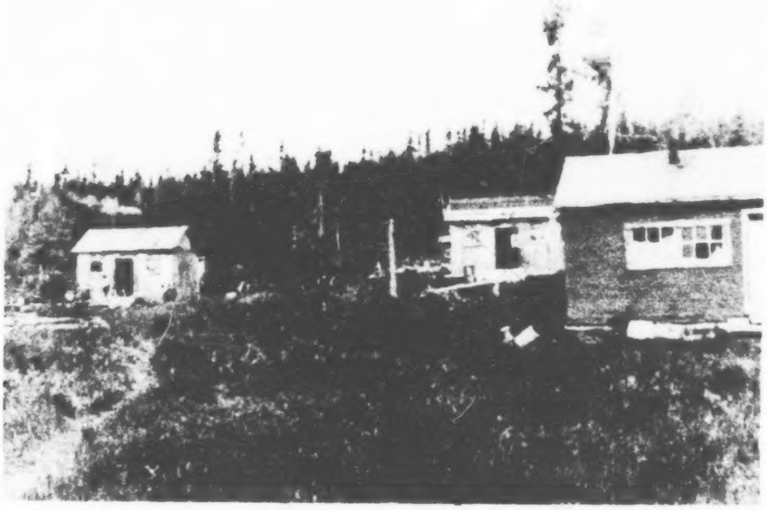
3. Building 'A' (Fish House) at Camp No. 1
(1972/161-#4)

4. Aerial View of Camp No. 1B
(1972/161-#6)

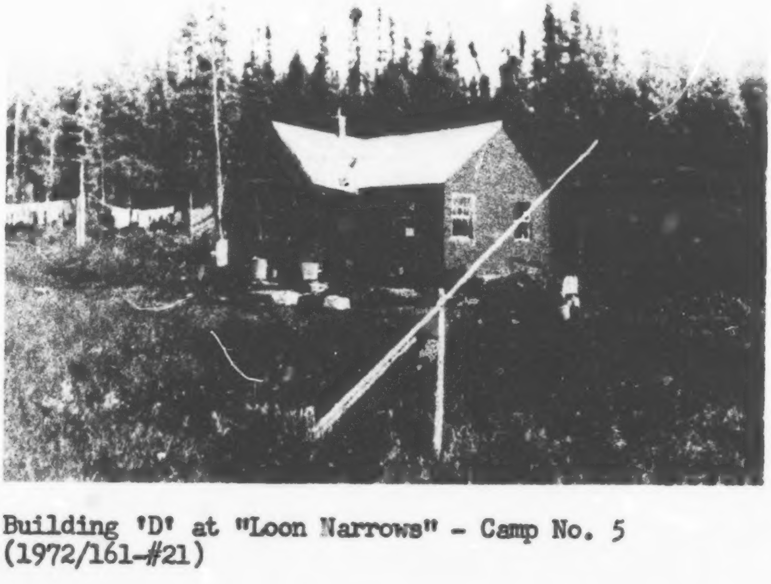


5. Buildings 'B', 'E' and 'A' at "Loon Narrows" - Camp No. 5 (1972/160-#1)

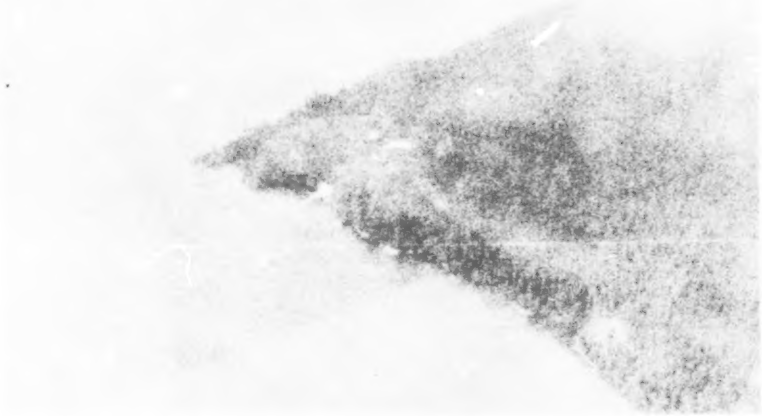
6. Building 'F' at "Loon Narrows" - Camp No. 5 (1972/161-#19)



7. Buildings 'G', 'H' and 'E' at "Loon Narrows" - Camp No. 5 (1972/161-#20)



8. Building 'D' at "Loon Narrows" - Camp No. 5 (1972/161-#21)

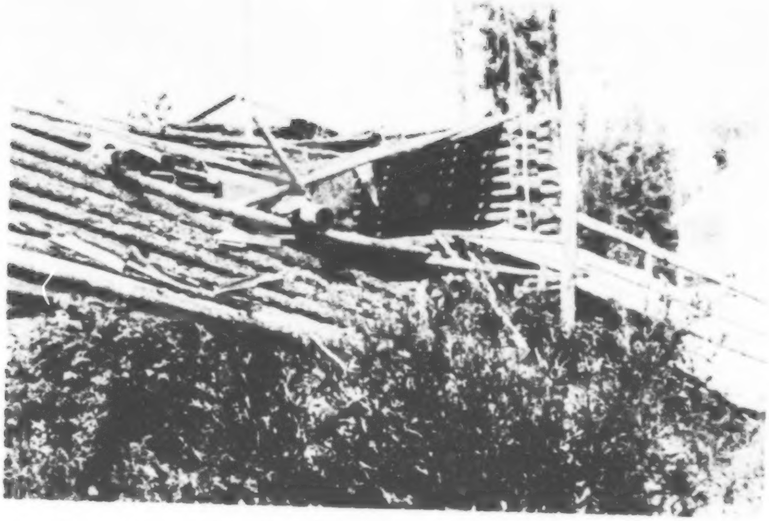


9. Aerial View of Camp No. 7
(1972/160-#8)

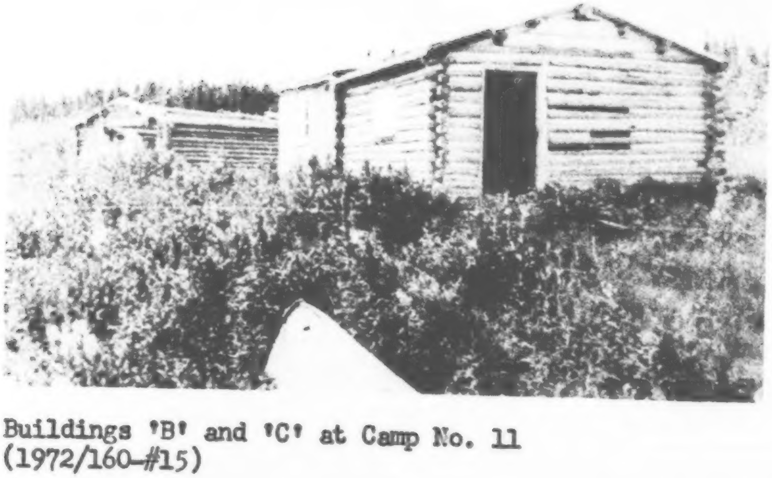
10. Aerial View of Camp No. 8
(1972/160-#9)

11. Aerial View of Camp No. 10
(1972/157-#7)

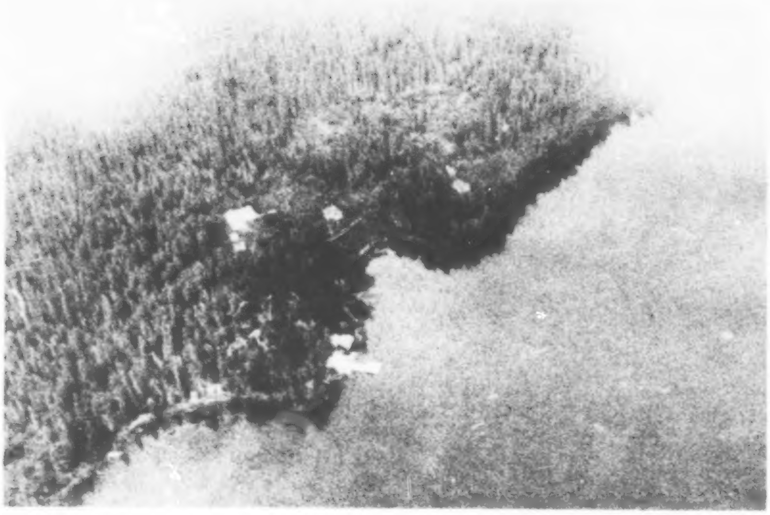
12. Building 'E' (Fish House) at Camp No. 11
(1972/160-#13)



13. Building 'D' (Ice House) at Camp No. 11
(1972/160-#14)



14. Buildings 'B' and 'C' at Camp No. 11
(1972/160-#15)



15. Aerial View of Camp No. 13 - Owen Ashley Fish Camp"
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EFFECTS OF INCREASED FLOW IN THE BURNTWOOD RIVER ON SHORELINES NEAR THOMPSON, MANITOBA

EFFECTS OF INCREASED FLOW
IN THE BURNTWOOD RIVER
ON SHORELINES NEAR THOMPSON, MANITOBA

by

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March, 1973

sub-contracted by:

Water Resources Branch
Manitoba Department of Mines, Resources and Environmental Management
Winnipeg, Manitoba

for

THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SPECIAL NOTE

THE CONCLUSIONS AND RECOMMENDATIONS CONTAINED IN THIS APPENDIX ARE THOSE OF THE AUTHOR(S) AND ARE NOT NECESSARILY THE SAME AS THE CONCLUSIONS AND RECOMMENDATIONS OF THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD AS EXPRESSED IN THE SUMMARY REPORT AND THE TECHNICAL REPORT.

EFFECTS OF INCREASED FLOW
IN THE
BURNTWOOD RIVER NEAR THOMPSON, MANITOBA

FOR:

The Water Resources Branch,
Department of Mines, Resources
and Environmental Management.
Province of Manitoba.

BY:

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Winnipeg, Manitoba
March, 1973.

ABSTRACT

This brief study evaluates the present regime of the Burntwood River near Thompson, the state of the river banks, and the extent of low lying facilities, and then predicts the effect of increasing the flow to a maximum of 35,000 cfs.

Field and office studies indicate that a conservatively estimated 15 foot rise in water levels will take place. The effects of this rise are limited but will necessitate the raising of the municipal water supply pumphouse floor, the relocation of the Air Services buildings and power boat docks to adjacent higher elevations, and partial dyking around a yet undeveloped portion of the cemetery. Erosion protection of the right bank near the sewer outfall may be necessary but the exact nature of this protection requires model studies, or can be left to be determined once actual increased flows are established.

The nature, extent of occurrence, and effects of thawing of permafrost in the riverbanks under conditions of raised river level were examined. On this basis, it is considered that permafrost thawing will have little if any effect on river bank stability. The river banks should remain stable unless the control works are operated in a manner that results in large and rapid changes in water level, in which case, more extensive geotechnical investigations would be necessary in order to evaluate bank stability.

The construction of the Manasan Dam and ancillary dykes will necessitate the raising of approximately four miles of the Thompson-Lynn Lake Highway, or ten miles of rerouting around inundated areas.

INTRODUCTION

The Water Resources Branch of the Manitoba Department of Mines, Resources and Environmental Management has undertaken the responsibility for co-ordinating the "Erosion and Sedimentation" component of the Lake Winnipeg and the Churchill and Nelson Rivers Study. One sub-component of this component involved studies of defined problem areas. Three such areas were identified and approved for study for 1972/73, namely:

i. Dredge Spoil Deposits of Two-Mile and Eight-Mile Channels.
ii. Operation of Two-Mile and Eight-Mile Channels.
iii. The Burntwood River at Thompson.

A report dealing with the first two topics entitled, "Dredge Spoil Studies and Aspects of Channel Operation" was submitted to the study office in July, 1972. The third topic is dealt with in the following report.

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TERMS OF REFERENCE

The planned diversion of water from the Churchill into the Nelson River system will materially increase the flow in the Burntwood River. This report deals with the effects of the increased flow in the Burntwood River near Thompson, Manitoba.

For the purposes of this study, a value of 35,000 cfs. was used as the maximum flow, consisting of the natural Burntwood River flow plus the flow diverted from the Churchill River system. Higher flows were not considered as the extrapolation of known conditions would be difficult without hydraulic model studies. It is noted that the flow of 35,000 cfs. corresponds to the maximum allowable flow as stipulated by the project licence granted by the Province of Manitoba.

This report is based on topographic surveys, hydraulic and soils information obtained during the summer of 1972 and extensive data obtained from previous studies by the National Research Council, Manitoba Hydro, private consultants, and various government agencies.

The objectives of the study included:

(a) Determination of existing river regime, condition of banks and extent of permafrost,

(b) Prediction of increased water levels under the increased flows,

(c) Prediction of future river regime, effects of inundation on low lying areas and facilities, and future bank stability, and

(d) Comment on possible mitigation measures if required.

SCOPE OF THE STUDY

The study commenced with a gathering of relevant reports and data from various agencies and consultants, namely Manitoba Hydro, Water Resources Branch, and Underwood McLellan and Associates Ltd. This phase of the study was carried out primarily by Mr. D. Andres, engineering aid. One of the more difficult problems encountered was to sort out the various survey datums used by various agencies. The co-operation of Manitoba Hydro, Department of Highways and Municipal Planning Branch is gratefully acknowledged. A reconnaissance field trip was undertaken in June by the authors and Mr. Andres to assess the best means of obtaining the required data. Discussions were carried out with the City Engineer as well as with INCO engineers and their assistance is gratefully acknowledged.

A hydrographic survey was carried out in July by field personnel from the Water Resources Branch and Mr. Andres. Cross-sections, bank profiles and water surface slopes were obtained at this time. A subsequent geotechnical survey was completed in September with borehole drilling carried out by Midwest Drilling under the direction of Professor A. Baracos and Water Resources personnel.

GEOLOGICAL AND SURFICIAL FEATURES NEAR THE BURNTWOOD RIVER THROUGH THOMPSON

Glacio-lacustrine sediments, glacial outwash and till constitute the surficial deposits in the Thompson area. These were laid on the relatively irregular, rolling glacial-scarred Precambrian bedrock surface. Low areas on the bedrock and the till received more lacustrine deposits than did high areas, to produce a more level, gently rolling plateau ranging in elevation between 650 to 700 feet GSC. Photo 1, looking northward, shows this plateau on which the City of Thompson is located.

The location of the Burntwood River through the Thompson area (Figure 1) follows valleys in the bedrock which outcrops at several locations, for example, at the proposed Manasan Dam Site (Figure 10), at Cross-Section 4, and at the Thompson Bridge (Figure 7). These outcrops, as well as the glacial till, constitute both vertical and lateral control. There is no evidence of meandering to indicate that the Burntwood has had other than its present channel through Thompson since the lacustrine sediments were deposited during the end of the last ice age, some 7000 to 9000 years ago as estimated by geologists.

Thompson lies on a 50 mile wide zone of gneissic rocks extending from southwest to northeast. These and adjoining sediments with some volcanic formations to the North, and volcanics with intercalcated sedimentary formations to the South, appear, on the basis of borings reported by others and visual examination of outcroppings, to be structurally sound.

Figure 7 shows the bed elevation of the Burntwood River ranging between elevation 580 to 590 in the Thompson area. The right bank of Cross-Section 1 (Figure 3A) shows one of the typical steeper river banks having a slope of approximately 4 horizontal on 1 vertical, and an over-all height from river bed to bank shoulder of about 80 feet. The left bank at this same cross-section shows one of the more gentle slopes, where a rise of 20 feet takes place in slightly over 400 feet. Judging from the tree growth and the absence of slide scars, the banks appear to have been stable for a very considerable length of time. Two exceptions are to be found. The first consists of some minor instability at the water's edge as shown in Photo 9, and the second the instability associated with gullying.

Small tributary streams carrying spring run-off and other surface waters have formed several gullies in the banks, some of which are between 2000 to about 5000 feet long. The vertical drop of some 50 to 80 feet along the gully gives sufficiently high velocities to erode lacustrine sediments, some of which contain permafrost. Figure 1 shows the location of these gullies, some of which have, in recent developments, had storm drainage, etc. diverted into them. The hills north of Thompson, such as the hill south of the airport, which is a source of local gravel, are terminal moraines. Since the moraines pre-date the lacustrine deposits, their full extent is hidden by covering clays and silts. The gravel pits appear in the upper part of Photo 1. The base of the gravel hill is indicated by the 750 contour adjacent to the highway, south of the airport in Figure 10.

SOILS ALONG THE RIVER BANKS

Detailed soils properties are given in several reports, Johnston et al (1), Goodman and Hardy (2) and Underwood McLellan and Associates (3). The test holes drilled as part of the present study and shown in Figures 3A, 3B and 3C confirm that the river bank soils are similar to those previously reported.

In order of increasing depth below the organic cover of moss etc., the soils include:

(a) A dark brown clay layer of a few feet thickness. The clay consists of very fine particles deposited towards the end of the glacial lake period.

(b) Layered lacustrine deposits of clay and silt, usually described as varved clays. The silt occurs generally in light colored layers ranging from about ½ inch to 3 inches in thickness. These soils are generally brown in color in the upper 12 to 17 feet, and where found at greater depths, are predominantly gray. The thickness of varved clay is limited by the depth at which the underlying glacial deposits or bedrock are encountered in relation to ground surface elevation. For example, in Cross-Section 6, the varved clays form a blanket up to 25 feet thick over the sloping underlying dense silty sand. Cross-Section 6 shows unconfined compressive strength ranging from 1850 to 2900 psf for the unfrozen varved clays. These are in the range of 1600 to 4600 psf for the brown clay and 200 to 4600 psf for the grey clay as quoted by Goodman and Hardy (2). They attribute the low values of 200 psf to disturbance during sampling for samples obtained at great depth, rather than representing low in-situ strengths. Samples tested from the Manasan dam site show unconfined compressive strengths ranging as high as 6080 and averaging about 2160 psf.

Cross-Section 6, shows four unconfined compressive strengths ranging from 375 to 715 psf for the varved clays that have had been sampled in frozen condition, and tested in a thawed unconsolidated condition.

Based on classification tests, the clay portion of the varves would be described as highly plastic having liquid limits in excess of 60. The silts having liquid limits under about 40, would be classified as relatively non-plastic. The silts would have appreciably higher permeabilities than the clays. Under the action of falling water such as occurs when small tributaries flow down the banks, both materials will erode severely.

(c) The glacial outwash overlying bedrock shows up in Cross-Sections 2, 3, and 6. It is largely silt and sand in composition. Little strength data are available for this material but the experience of drilling at Cross-Sections 2 and 3 indicate it would be classed as a very hard material. A single triaxial test reported by Baracos and Marantz (4) showed a value of 30 degrees for the angle of internal friction, not inconsistent with standard penetration values ranging from about 12 to 15. Higher standard penetrations, as high as 30 to 33, corresponding to relatively hard material, were also encountered by Baracos and Marantz (4).

PERMAFROST IN RIVER BANKS

The occurrence and nature of permafrost in the Thompson area has been documented in several reports. Baracos and Marantz (4), in 1959 showed the occurrence of permafrost in the riverbank shown in Cross-Section 6 (Figure 3C) although no permafrost exists there now as shown by recent construction and by a test hole drilled in 1972 as part of the present study. The clearing of vegetation and the construction of a water main has caused the disappearance of the permafrost in the intervening time. Permafrost, however, was still found nearby at Cross-Section 6 (Figure 3C) in bank not cleared of sphagnum moss and tree cover. Underwood McLellan and Associates (2), in an investigation of the Manasan Dam Site, drilled 10 test holes on the river banks. Two holes showed permafrost to a depth of 14 feet, and one hole to a depth of 8 feet, and the remaining six holes indicated no permafrost.

Drilling undertaken as part of the present study indicated the absence of permafrost on the right bank of Cross-Sections 2, 3, and 6 (Figures 3A, 3B, and 3C). Limited drilling on the left bank also showed locations free of permafrost at Cross-Section 1 and about midway between Cross-Section 1 and 2.

Johnston, Brown, and Pickersgill (1), in 1963, described the terrain features which would most likely be associated with the occurrence of permafrost in the Thompson area. These include: sphagnum moss cover, and/or sparse to moderately dense spruce growth, and reasonably good drainage. The less intense solar radiation received on northward dipping slopes appears to be a possible additional factor favoring permafrost.

Data on Thompson, presented by Goodman and Hardy (2), and by Johnston et al (1), indicate that permafrost occurs in patches. It is occasionally found as deep as 30 to 40 feet, but generally is shallower than 13 to 15 feet. Measured temperatures of the permafrost are near thawing (32°F). Sufficient evidence is available to indicate that a site stripped of vegetation will cause disappearance of permafrost in a period as short as one or two years although complete reconsolidation of the soil requires considerably longer. Ice segregation observed in the permafrost includes closely spaced ice lenses ranging from fractional inch thickness to occasionally as much as six inches; randomly oriented, fractional-inch thick lenses have also been observed. In some cases the ice is not visible to the naked eye but its presence is noted when thawing destroys the bonding between particles and softening results.

Year-round flow in the Burntwood River has assured the absence of permafrost in the riverbed. W.G. Brown (5), in 1962, presented a simple graphical method for estimating the location of permafrost under rivers. Application of this theory with slight modification to take into account the rather long flat slopes of the river banks in the Thompson area, confirms theoretically the absence of permafrost under the river. It also shows that where permafrost is present it would be found theoretically as shown in Figure 4A, and as was actually found in Cross-Section 6(Figure 3C). Heat from the river and from geo-thermal sources would restrict the permafrost to a relatively thin layer below the depth of seasonal freezing and thawing, roughly parallel to the ground surface. The permafrost tapers towards the river resulting in no permafrost near the water's edge. At the upper part of the slope the thickness of the permafrost would correspond to the values quoted from Goodman and Hardy (2), Johnston, et al (3). Figure 4 shows qualitatively, in sketch-form, how the permafrost is theoretically affected by a raised river level and warmer river flow, both of which cause the permafrost taper to recede up the slope. Also shown is the complete disappearance of permafrost when vegetation cover is thinned or removed.

It was fortunate that data was available on banks that had undergone thawing of permafrost in Thompson. The thawing at Cross-Section 6 had taken place with beneficial results. It was possible to place a buried watermain up the bank during a recent extension of the water system, where earlier the construction had to use a pipe above ground to prevent damage from settlement resulting from the thaw. Careful examination of this bank in 1972 indicated no instability due to permafrost thawing, although evidence of recent gullying was observed along a drainage ditch parallel to the pipe line (Photo 7).

Recent permafrost thawing appears to have occurred on the right bank between Cross-Section 2 and 3 due to removal of the under-brush and thinning of trees during the construction of a road and picnic sites. Photo 10, taken at Cross Section 2 shows the present tree cover. Two test holes at this cross-section indicated no permafrost, although considerable seepage was encountered, and the holes filled with water to within a few inches of the ground surface within a day after they were drilled. A likely source of this water is thawed ice lenses from permafrost of seasonally frozen ground. The moss-cover at Cross-Section 2 had shifted down slope in a few locations forming the crack noted in Figure 3B. Some manual excavation indicated the movement was taking place along the wet interface of moss and soil and involved mostly moss.

Other banks where permafrost thawing has likely taken place include the area in the left bank near Cross-Section 2, where a forest fire has destroyed the vegetation cover, and several areas where construction such as for sewers, roads, etc., has taken place. Johnston et al (1), quotes geological evidence to indicate that prior to 2500 to 3000 years ago, mean annual temperatures may have been as much as 5°F warmer than at present. The opinion is **offered** that the permafrost at Thompson was not present during this warm period. Since the banks are older than 2500 to 3000 years, and they have not materially changed in slope during this time, they very likely had the same slopes in the past with no permafrost present.

PRESENT STABILITY OF BURNTWOOD RIVER BANKS THROUGH THOMPSON

The banks were examined for signs of existing instability and were found generally stable except for the following cases:

Instability Associated with Gullying

The severest example of this instability occurred on the side slopes of the stream shown in Photo 14. A drainage system was constructed to divert existing flow from areas south and east of the Thompson Railway yards, in a northwest direction to the Burntwood River, as shown in Figures 1 and 10. A fairly substantial flow down the right bank of the Burntwood, where the average gradient is about one foot drop in twenty feet, resulted in gullying and related instability. The stream's velocity was high enough to cause deepening erosion of the varved clay and silt bed of the stream. Heat from the stream flow also assisted in thawing of the permafrost, where present in the bed, and produced even more rapid erosion. With the channel becoming deeper, the side slopes lost their base support, and commenced to slide. The action did not stop until non-erodible material was reached (or placed) in the stream bed. The wide area with no trees from one side to the other side of the stream shown in Photo 14 is the result of the sliding and the necessary measures to subsequently control erosion and sliding.

Photo 13 shows a similar effect on a typical gully in the right bank between Cross-Sections 2 and 3. The effects of gullying, and the instability of recent fill was also observed in the gully just east of the Thompson Bridge. Photo 7 shows recent gullying where a drainage ditch, near a recently constructed watermain (Photo 6) has had erosion of its bed. Permafrost was not a factor in this case, since the ditch was excavated in soil which has been permafrost-free for several years.

Instability at Water's Edge of River

Photos 8 and 9 show instability localized near the water's edge. It is believed that wave action from wind and possibly power boats has undercut the support for trees adjacent to the water's edge. Movement of soil at a shallow depth, and extending as much as 20 feet back from the water's edge, is involved. This action was observed at only one location just downstream from Cross-Section 2, on the right bank.

Instability Associated with Permafrost Thaw

Mention has already been made of the role of permafrost in gullying but the gullying action would undoubtedly take place and result in unstable gully side slopes without the permafrost associations; somewhat more time would be required.

Cross-Section 6 represents a documented case where permafrost thawing in a river bank as a result of tree and underbrush clearing has not caused sliding. Similarly at Cross-Section 2, recent park development on the bank has perhaps resulted in some superficial movement of moss down a slope but there is no indication of deeper soil movements.

It is possible to hypothesize permafrost thaw conditions in which rapid thawing without drainage would result in slope instability. These conditions have apparently not occurred in the Thompson area for a number of reasons:

1. Only some river banks have had permafrost.
2. The permafrost is not sufficiently deep in the majority of cases to weaken deep-seated support. The average depth of permafrost, being 14 to 15 feet, would not affect deep-seated support of the approximately 80 feet high banks.
3. The soils constituting a substantial portion of some banks are bedrock and other materials not adversely affected by permafrost.
4. The rate of thawing has been sufficiently slow, even with the relatively rapid removal of vegetation cover as in Cross-Section 6, to permit adequate gain of soil strength as thawing proceeds.
5. The Burntwood River is a year-round heat source resulting in reduced or no permafrost for some considerable distance adjacent to the river.

Instability Associated with Toe Erosion

Cross-Section 1 shows localized sliding of toe at the right bank, immediately west of the sewer outfall. This appears to be associated with the dissipation of stream energy below the falls at the Thompson Bridge site. The enlarged "pool" below the falls may be the result of continued erosion over many centuries from this same cause. The exposed face of the eroded bank was examined and found to consist of lacustrine sediments. Similar erosion was not observed elsewhere.

Instability of Fill on Banks

A crack in the back-fill of the sewer outfall at the shoulder of the bank, as shown in Cross-Section 1, is likely due to the incipient movement of weaker back-fill. Landscape fill on the east side of the south approach to the Thompson Bridge shows movements near the water's edge, and these are likely due to the weak nature of uncompacted fill.

HYDRAULICS OF THE BURNTWOOD RIVER AT THOMPSON

Hydrology

The basin of the Burntwood River stretches from the west boundary of Manitoba to Split Lake, located at the junction of the Nelson River. The flow in the river, at Thompson, reaches a peak during the month of June, primarily as a result of snowmelt and local rain. During the winter months the flow is reduced to approximately 1000 cfs. Flow records over a period of 15 years indicate that the mean flow is 5800 cfs. while the maximum experienced flow was 20,400 cfs, on June 19, 1966 (instantaneous peak).

Water Levels

Measurements of discharge and water level have been carried out at the water supply pumphouse (upstream of Cross-Section No. 5) by Water Survey of Canada. Water levels have been measured since 1957 by INCO.

This information resulted in the discharge rating curve shown in Figure 5. The plotted points form a smooth curved line on log-log paper; however, it is difficult to extrapolate this line to higher discharges. As an estimate of extreme high water levels a straight-line extrapolation was used to give conservatively high values. (See Figure 5). Using less conservative curved extrapolation would result in levels being 3 to 4 feet lower. The range of water levels experienced in the past was some 8 feet; the range of future water levels will depend upon the manner in which the Churchill Diversion is operated.

Present river stage levels during the winter, with an ice cover over the river, have been found to be slightly higher than the levels for identical summer discharges. The existing data is for low winter discharges. Hydraulic model studies as well as a detailed study of ice processes would be necessary in order to venture a precise prediction of winter stages under high discharges, and to determine possible flow controls in the Diversion so that a stable ice cover is developed, ice jams are minimized, and water levels are not excessively high.

Water levels were also measured upstream and downstream from the Thompson Bridge in order to establish a relationship between water levels at these locations. The data obtained during the summer of 1972 is plotted in Figure 6 and shows that a difference of 2.5 feet exists between the water levels. This is, however, for a limited range of low flows; and would likely be reduced at higher flows. For this study a 2.0 feet drop at higher flows, considered conservative, was adopted.

Velocities

The velocities along the river are extremely low; during field measurements with a discharge of 8400 cfs. the velocity was approximately one foot per second. The river behaves more like a lake than a river with its stage being controlled by the bedrock outcrop at the Thompson Bridge (Figure 7). For the future flow of 35,000 cfs. the velocities will increase to approximately 2.5 feet per second · the variation in velocity along the river adjacent to Thompson is shown in Figure 8.

Hydraulic Characteristics at a Station

A plot of width and mean flow depth versus discharge is shown in Figure 9. The width does not increase quickly with discharge. A comparison of the derived relationships with other similar relationships is as follows:

	Burntwood River	Other Rivers
Width	$b = 145\ Q^{0.12}$	$b \propto Q^{0.26}$ (leopold, et al)(6)
Depth	$d = 0.9\ Q^{0.31}$	$d \propto Q^{0.40}$

The relationships differ significantly from accepted relationships for other rivers which would indicate that the present spectrum of flows is not actively forming the channel. The river is controlled by the bedrock outcrop at the Thompson Bridge resulting in much lower velocities than could occur if the channel and its boundary controlled the levels.

PREDICTED EFFECTS OF INCREASED FLOW

Inundation of Low Lying Areas and Facilities

Figure 1 shows in plan, and Figures 3A, 3B and 3C in typical section, the extent of inundation that will take place when the Burntwood River flow is raised to 35,000 cfs. through Thompson. The depth of inundation is somewhat affected by the backwater of the proposed First Rapids Dam. With the dam the depth will be as much as one foot higher downstream from the Thompson Bridge, and approximately one foot higher upstream from this Bridge as compared to conditions without the dam. In terms of elevation the estimated maximum elevation of water will be 619 feet, just upstream from the Thompson Bridge. (Elevations given are Canadian Geodetic Surveys Datum unless otherwise stated. Please note Figure 1, uses INCO Datum.)

The extent of inundated land is limited by the banks whose height will be anywhere from 35 to 55 feet above the raised water elevation. The following low lying areas or facilities will be affected:

(a) Raised water levels will be at the operating floor level (El. 619.0) of the Thompson Waterworks Pumphouse shown in Photo 4. Superimposed on Photo 4 is the estimated maximum high water mark with 35,000 cfs. flow and backwater from First Rapids Plant. The pumphouse will require modification to account for the higher level. An off-setting advantage will be the reduction in pumping height which can lead to pumping economies.

(b) Photo 11, shows the Thompson Bridge. The elevation of the top of the piers is well above anticipated high water.

(c) Photo 12, shows part of the Air Services area on the left bank. The river level with 35,000 cfs. flow and the First Rapids Dam will inundate approximately a 400 feet wide strip along this bank as shown in Cross-Section 1 of Figure 3A. The new water's edge will be just beyond the edge of the gravelled area shown in Photo 12. The buildings shown are of relatively light timber construction on shallow foundations, and can be easily moved to new locations higher up the bank.

(d) Cross-Section 1 shows the raised water level at the site of the sewer outfall. The main effect here will be to submerge the discharge end of the sewer outfall. Year-round increased dillution of the effluent will be a beneficial result. Bank erosion at this location may increase, as is later discussed.

(e) Figure 1 shows the location of the Thompson Cemetery in relation to raised water's edge. To date, only the westerly portion has been developed, and this will not be inundated. Dyking, or development away from the river will be required to limit the effects of the flooding of the easterly section. Examination of pre-dug graves (for future use) showed that existing drainage was very poor and the grave holes were filled with water. This condition is not related to the river level.

No residential or commercial areas or utilities other than the five already mentioned will be inundated by the raised Burntwood River. The width of the river will increase between about 10% to 80% of its present width through Thompson. East of Cross-Section 1, where the river banks are relatively less steep, a lake approximately triple the present river width will form.

Most of the area to be inundated is covered by tree growth as shown in Photos 1, 3, 5, 8 and 9. These will require clearing before inundation to give a shore-line at higher elevation comparable to the present shoreline.

Future Stability of Banks

Theoretically, detrimental effects on the banks due to increased flow include the loss of stability from rapid permafrost thaw, and that of erosion. There is similarily a beneficial stabilizing effect due to buoyancy on submerged soils.

With regard to permafrost, its occurrence in the banks is patchy, of limited depth, and it does not occur under the river. Heat from the river tends to keep permafrost a certain distance away from the water's edge. Soils that are adversely affected by being frozen, are also limited in extent to which they occur in the banks. Considering these factors, and also the raising of levels a maximum of about 12 to 15 feet in relation to the 70 to 80 feet height of the banks, it is considered that permafrost thawing will not be a serious problem affecting stability. It has already been shown that river banks cleared of vegetation have thawed without sliding. The clearing of the entire slope of vegetation and resulting rapid thaw imposes very severe conditions. The heat balance is disturbed over the entire slope, whereas with the 12 to 15 feet rise in the river the major disruption of the heat balance is near the water's edge and only part way up the slope. In this latter case, the thaw occurs where there is also less permafrost to be adversely affected.

On this basis it is expected that thawing of permafrost will not lead to serious sliding. The possibility of such sliding can be further minimized by removing the tree cover from the portions of bank to be inundated, two to three years before the inundation takes place. This will induce any existing permafrost to thaw before inundation. The present parks development of the banks has this beneficial effect.

Raising the river will not cause gullying. The cause of gullying is the steep gradient down the banks of natural or man-made tributaries which erode their beds in the lacustrine sediments forming the banks. The Burntwood River, however, does not have the gradient nor the erodible bed to undergo such erosion.

The mean velocities of 2.32 to 2.84 feet per second (1.57 to 1.93 miles per hour) predicted for 35,000 cfs. flow as shown in Figure 8, are considered low and are not normally associated with erosion. There does exist the possibility of velocities considerably higher than average at some locations where erosion may occur. One such apparent location is below the rapids at the Thompson Bridge site. As has already been noted, the right bank at this location currently shows erosion, and some incipient instability of recent fill. Approximately a 4000 feet length of bank is involved. Relatively simple measures can be taken to protect the bank. These include the placing of rip-rap on the portion of bank to be submerged, or the construction of current-deflection groins. To determine fully to what extent these measures are warranted would require a hydraulic model study, or alternatively, provision for their construction should be based on actual experience after raising the river level. Minor erosion from wave action similar in extent and effect to what is now occurring (Photo 9) can be expected at the raised water's edge. It may be necessary at some future time to control power boat operation on the river which can be a contributing factor to such erosion.

A further factor that has to be considered regarding erosion is the effects of fluctuating river levles. The lacustrine sediments, particularly the clays are adversely affected by alternate submergence, exposure to drying, and freezing and thawing. This increases their susceptibility to erosion. This action may increase the length of shoreline requiring rip-rap or similar protection.

The fluctuation of river levels can introduce a severe form of loading known as rapid draw-down. This condition results when the water submerging a bank is suddenly lowered, leaving the soils in a saturated weaker condition without the support of bouyancy.

The effects on the bank stability of the rapid draw-down can be considered comparable to, but not as severe as, the permafrost thaw case already considered, as only the lower portion of the banks will be subject to the water level fluctuations. The effects of repeated rapid draw-down can have a cumulative effect on the banks. It is highly desirable that extreme fluctuation in river level be avoided. At present it is not possible to evaluate the exact future rate of change in water level. If the future hydro plants along the Burntwood River are operated so as to give wide changes in river level, then detailed geotechnical studies beyond the scope of this present study would be essential.

The presence of First Rapids plant will desirably limit the extent of water level fluctuations and thereby minimize or eliminate possible draw-down effects.

EFFECTS OF LAKE FORMED BY MANASAN DAM

Figure 10 shows the lake that will be formed to the north and west of Thompson after Manasan Dam is built. Two shorelines have been indicated, one at elevation 675 and the other at 700 feet GSC. The proposed elevation is 690 (Manitoba Government Datum), but lack of more precise contour information prevented determination of the shoreline at this elevation. The dyke locations are approximate but in all cases selected to prevent flow into adjacent watersheds.

The lake will be approximately 30 miles long, and will back up water into the tributaries of the Burntwood River. This will necessitate approximately 4 miles of raising or 10 miles of re-routing, of the Thompson-Lynn Lake Highway which would be flooded by as much as forty feet of water. It has been noted that the gravel deposits just south of the Thompson airport are terminal moraines which may extend under the area to be inundated. This may lead to some seepage into the gravel workings, but because of the low permeability clay cover on the moraine the amount of seepage will likely be small.

It is important that overflows from the new lake be prevented by dykes from entering adjacent watersheds where it could cause gullying.

Some of the area to be inundated is muskeg. A suitable shoreline for summer resort use would require that trees be removed before inundation, where present tree cover exists.

With no dam at Manasan Falls, and the design flow down the Diversion, inundation of the Thompson-Lynn Lake Highway will not likely occur. An approximate estimate of inundation level is 640 GSC. Increased maintenance of the roadway may be necessary in the low lying short section below this elevation.

CONCLUSIONS AND RECOMMENDATIONS

The effects of increasing the flow from a mean daily flow of 5,800 cfs, in the Burntwood River to 35,000 cfs. due to diversion are summarized as follows:

Water Level Changes

a. The predicted water level at the water supply pumphouse will be elevation 618 (GSC) with a flow of 35,000 cfs. The construction of the First Rapids Hydro Plant will result in approximately a one foot higher level at the pumphouse. With little or no flow in the Burntwood the water level would probably coincide with the First Rapids reservoir level of 610 (GSC). The elevation of the pumphouse floor is 619.2 (GSC) and the raising of this floor will probably be necessary. Local boat mooring facilities will have to be raised.

b. The predicted water level below the Thompson Bridge will be at elevation 616 (GSC) with a flow of 35,000 cfs, and at elevation 617 (GSC) with the First Rapids Plant in place. This will necessitate the moving of the Air Services buildings to a higher level, the dyking of the cemetery and the protection of the steep banks near the sewer outfall.

River Bank Considerations

a. Presence of permafrost is limited and where found does not extend to river water's edge. Rapid thaw of permafrost can theoretically lead to instability.

b. Existing banks have been and are being subject to thaw of permafrost. Such a bank that had permafrost 15 years ago, has successfully carried a watermain above ground and recently a new watermain below ground showed no sign of instability.

c. Clearing of underbrush by the city of Thompson for riverbank park appears to have caused permafrost thaw sufficiently rapid to induce movement of moss cover on the slope. It is unlikely that thawing of riverbank permafrost due to raised river levels will be as serious as what has currently been caused by clearing of bank for the park.

d. Severe local instability of the bank has been caused by "gullying". This is due to flows from drains, etc. coming in at the top of bank. Resulting erosion and permafrost thawing have caused sides of gullies to slide.

e. Soils in banks consist of varved silty clay and clayey silt underlain by dense silt at various elevations. Bedrock is found outcropping in some locations. There is evidence of some present erosion at the water's edge that has led to narrow strips (20 feet wide approximately) showing incipient sliding. This erosion is probably caused by wind or power boat waves. Similar conditions will likely occur near raised water's edge.

f. Most banks are 50 feet to 80 feet high on slopes of about 4:1. The slopes do not feature scars, etc. to indicate past history of sliding except for local "gullying".

g. With predicted velocities of less that 2.5 feet/second it is unlikely that river flow will lead to erosion problems.

Manasan Dam

a. Tentative plans call for a forebay elevation of 690 feet. This would cause or require:

i. Water to back up a distance of about 12 miles in

Birch Tree Brook.

ii. Rerouting or raising by approximately 40 feet at certain locations of the Thompson-Lynn Lake Highway.

iii. Dyking along south side of Birch Tree Brook to prevent drainage into the Burntwood River. Such flow would cause gullying of the bank, slides, and result in increased turbidity in the Burntwood.

Respectively submitted on March 12, 1973.

PROVINCE OF MANITOBA
ANDREW
BARACOS
REGISTERED ENGINEER

A. Baracos

Professor A. Baracos, P. Eng.

PROVINCE OF MANITOBA
V. J.
GALAY
REGISTERED ENGINEER

Vic Galay

Professor V. Galay, P. Eng.

REFERENCES

(1) Johnston, G.A., Brown, R. J., and Pickervgill, D.N. - "Permafrost Investigations at Thompson, Manitoba, Terrain Studies", NRC Technical Paper No. 158, Ottawa, 1963.

(2) Goodwin, K.S. and Hardy, R.M. - "Permafrost Occurrence and Associated Problems at Thompson, Manitoba. Proc. 1st Canadian Conference on Permafrost, April, 1962

(3) Underwood McLellan and Associates - "Geological Investigations on the Burntwood River", Report to Manitoba Hydro, 1966

(4) Baracos, A. and Marantz, O., "Soil Mechanics Investigation, Proposed Water Line, Thompson, Manitoba", Report to INCO, 1959

(5) Brown, W.G. - "Simple Graphical Methods for Estimating the Location of Permafrost Under Shallow Lakes and Rivers", Proc. 1st Canadian Con. on Permafrost, April, 1962

(6) Leopold, L. and Maddock, T. - "The Hydraulic Geometry of Stream Channels and Some Physiographic Implications". U.S.G.S. Prof. Paper 252, U.S. Gov. Printing Off., 1953.

APPENDIX 1

Survey Datums Near Thompson, Manitoba

(a) G.S.C. = Man. Gov. Datum - 2.124 ft.

(b) G.S.C. = INCO Datum + 2.977 ft.

NOTE: All Manitoba Hydro Surveys are Man. Gov. Datum.

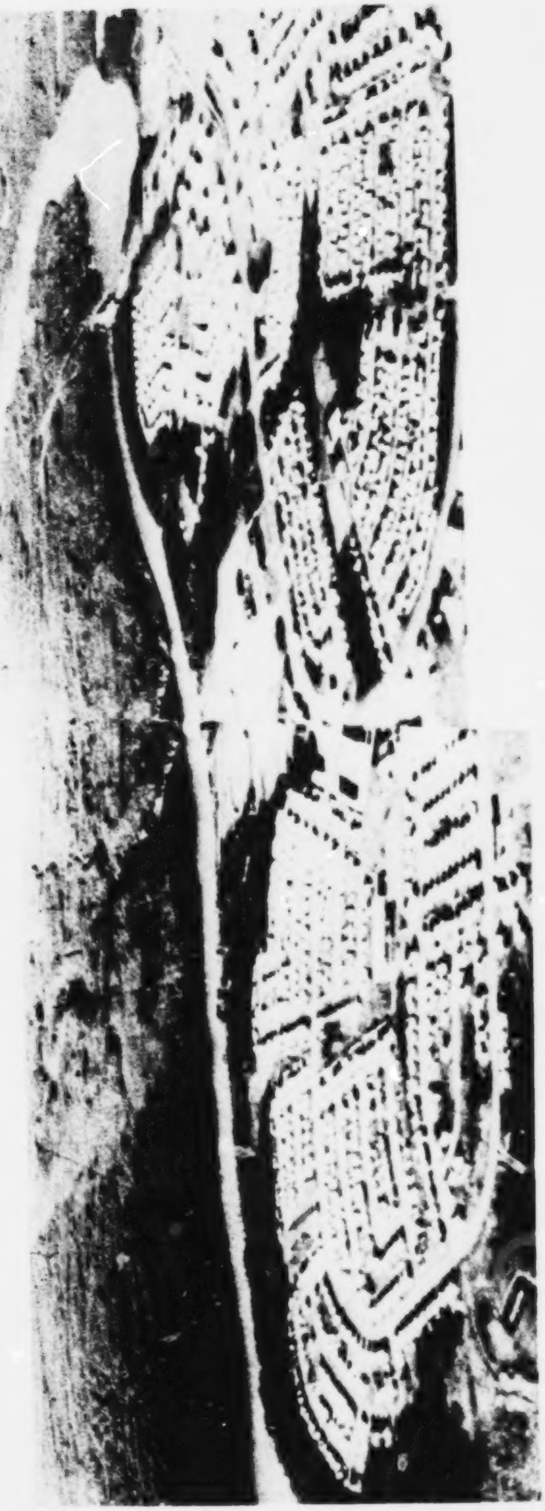


Photo 1
City of Thompson located adjacent to the Burntwood River. The city is located on a plateau approximately 75 feet above the river. Gravel pits are evident in the background.

Photo 2
Manasan Falls
Future Site of Manasan Dam. The water level is lowered by approximately 20 ft. by the falls.

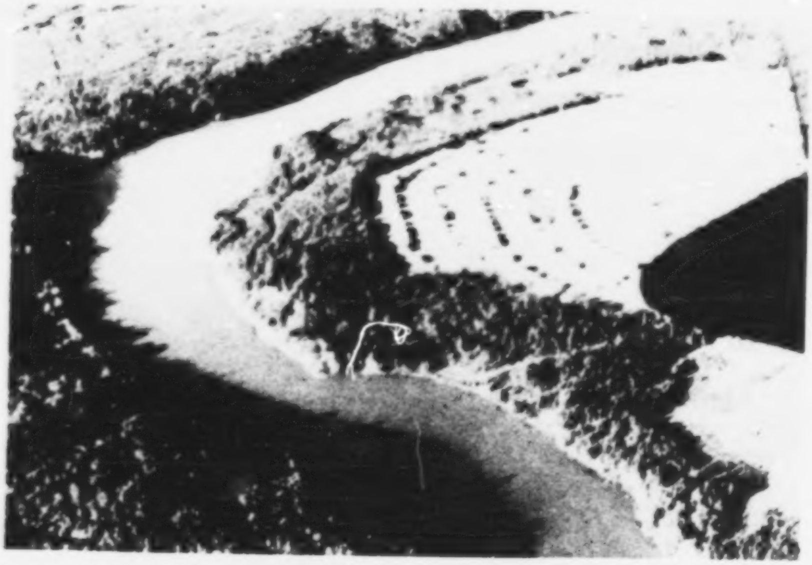


Photo 3
Bedrock point at Cross-Section 4, (Right bank constriction near centre of photo).

Photo 4
Water Supply Pumphouse, Located near Cross-Section No. 1. The main **floor of** the pumphouse is at the estimated high water level.

Photo 5
Burntwood River downstream from Pumphouse.

Photo 6
Pipeline leading from pumphouse. The bank of the Burntwood River has been cleared, but no slope instability is evident

Photo 7
Minor gullying along riverbank at pumphouse. Soil is being removed by rapid flowing local runoff.

Photo 8
Burntwood River, looking upstream to Cross-Section 4.

Photo 9
Minor slumping at base of riverbank probably due to waves caused by wind and/or motor boats.

Photo 10
Right bank of the Burntwood River near Cross-Section 2. The underbrush has been completely cleared during the past year for park development. The moss cover is now compacted and shows evidence of some surficial movement. The loss of underbrush is probably responsible for thaw of permafrost along this bank.

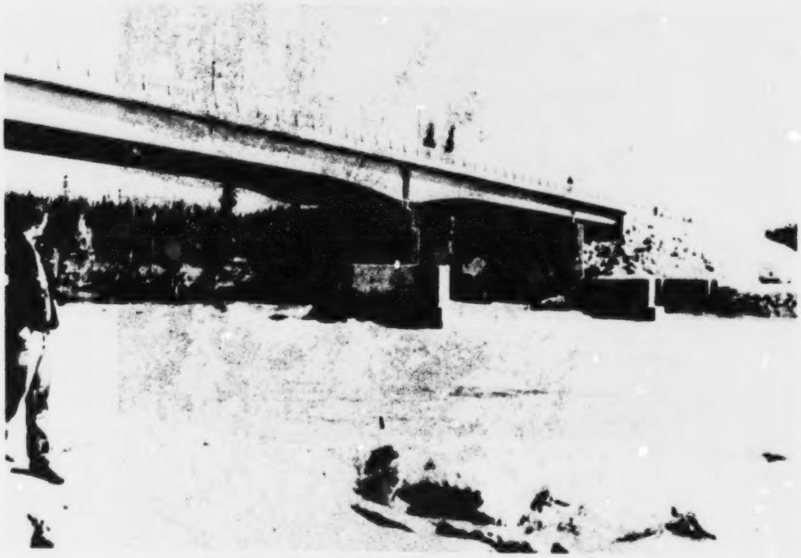
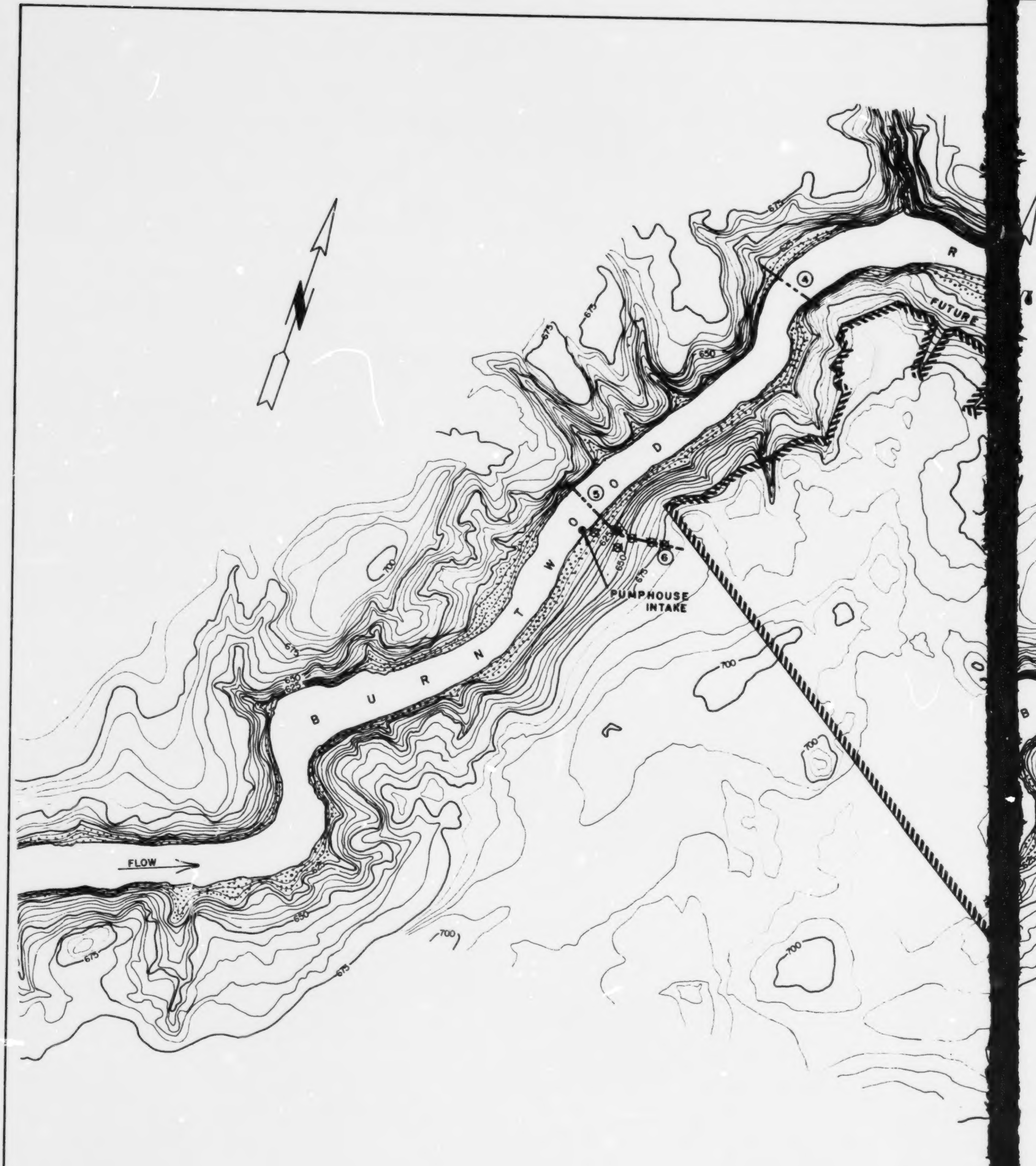


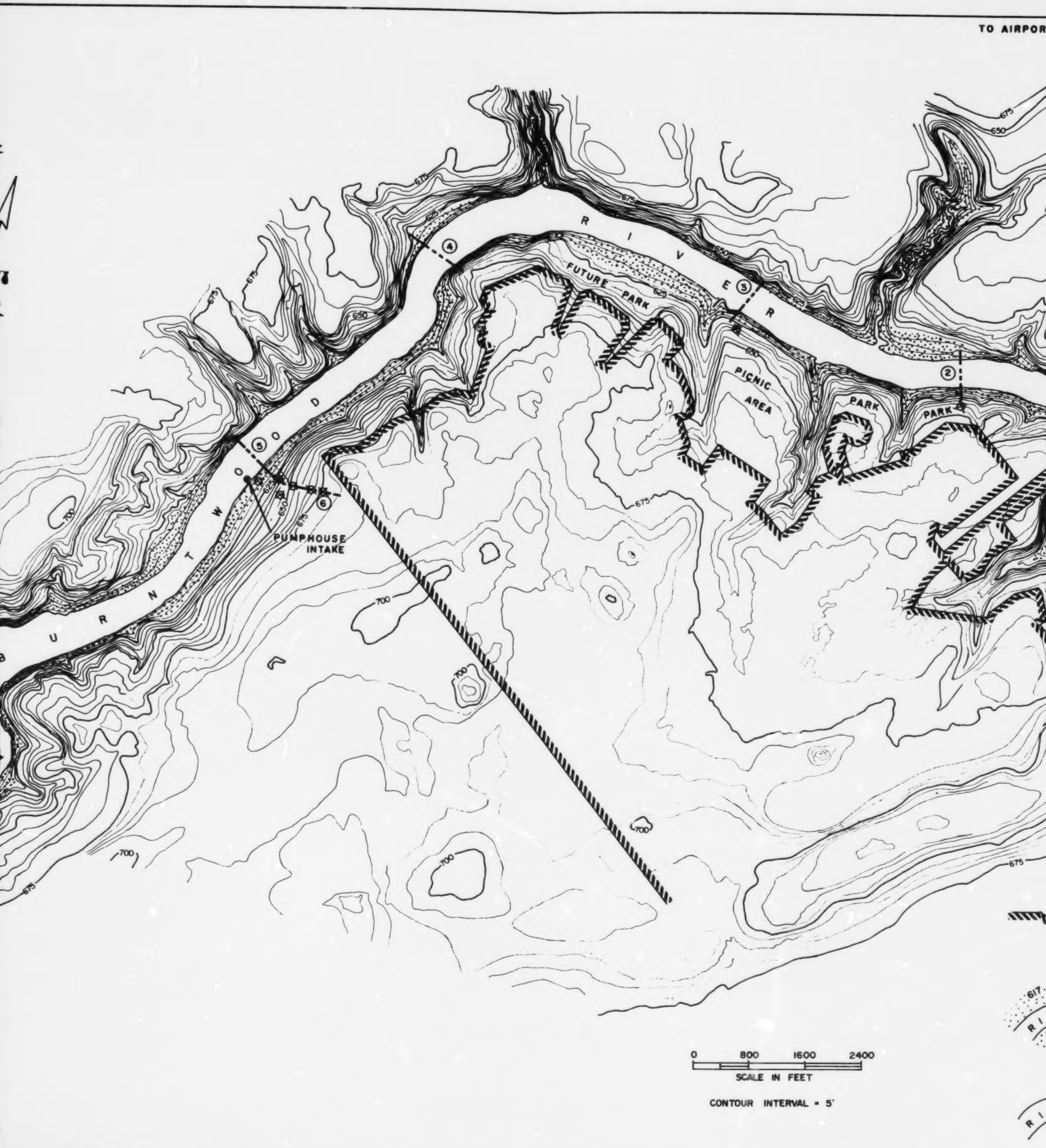
Photo 11
Thompson Bridge over Burntwood River. The water level drops 2.5 ft. over the falls. The predicted level with First Rapids Plant and 35,000 cfs. flow is about 7 ft. below the top of the pier of the new bridge.

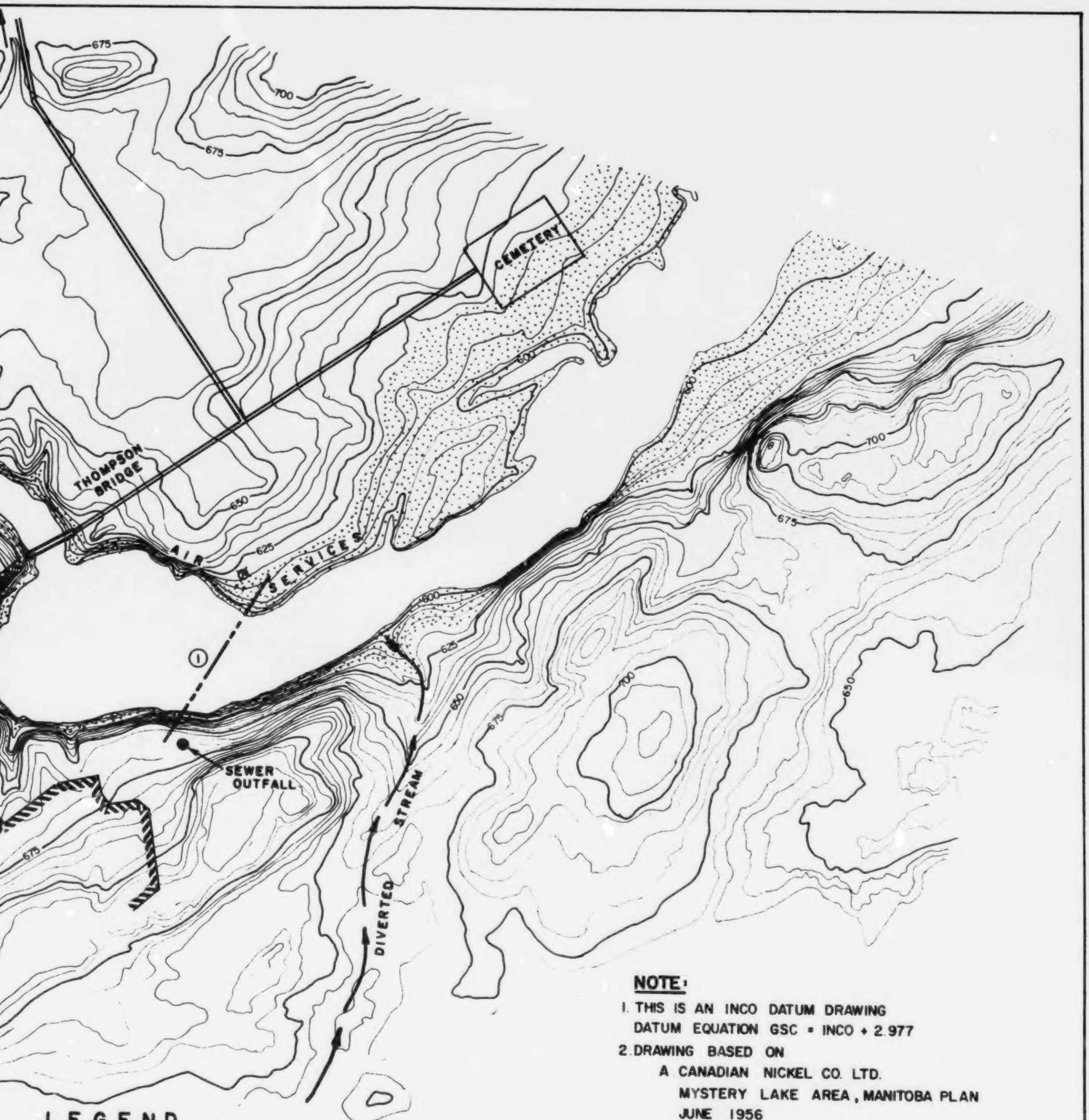
Photo 12
Air Services Facilities. The dock is located at a low level and will be flooded after Diversion.

Photo 13
Gullying on thr Right Bank of the Burntwood River between Cross-Sections 2 and 3. The gullying is due to increased local urban runoff from the city.

Photo 14
Protection of rapidly eroding gully by rip-rap. Extensive erosion has resulted from largely increased flows down the gully.


N
675
675
675
675
625
650
④
R
FUTURE
D
⑤
O
O
W
625
650
675
⑥
PUMPHOUSE
INTAKE
700
675
650
625
B U R N T W O O D R
700
700
FLOW
650
675
700
675
700
B


TO AIRPOR
B U R N T W O O D R I V E R
FUTURE PARK
PICNIC AREA
PARK
PARK
PUMPHOUSE INTAKE
①
②
③
④
⑤
⑥
675
650
625
700
617
R I
0
800
1600
2400
SCALE IN FEET
CONTOUR INTERVAL = 5'


675
700
675
CEMETERY
THOMPSON BRIDGE
650
625
AIR SERVICES
600
600
700
675
①
600
625
650
675
700
650
SEWER OUTFALL
DIVERTED STREAM
675

NOTE:

1. THIS IS AN INCO DATUM DRAWING
   DATUM EQUATION GSC = INCO + 2.977
2. DRAWING BASED ON
   A. CANADIAN NICKEL CO. LTD.
      MYSTERY LAKE AREA, MANITOBA PLAN
      JUNE 1956
      (COURTESY INTERNATIONAL NICKEL CO.)
   B. WESTERN PHOTOGRAMMETRY LTD.
      JOB NO. 1418-35, ROLL NO. YC 2001
      (COURTESY MAN. DEPT. OF MUNICIPAL AFFAIRS)

LEGEND

TOWN LOT LINE

LOCATION OF DRILL HOLES

AREA INUNDATED BY RAISING LEVEL TO ELEV. 617 INCO DATUM

APPROXIMATE LOCATION OF CROSS-SECTION

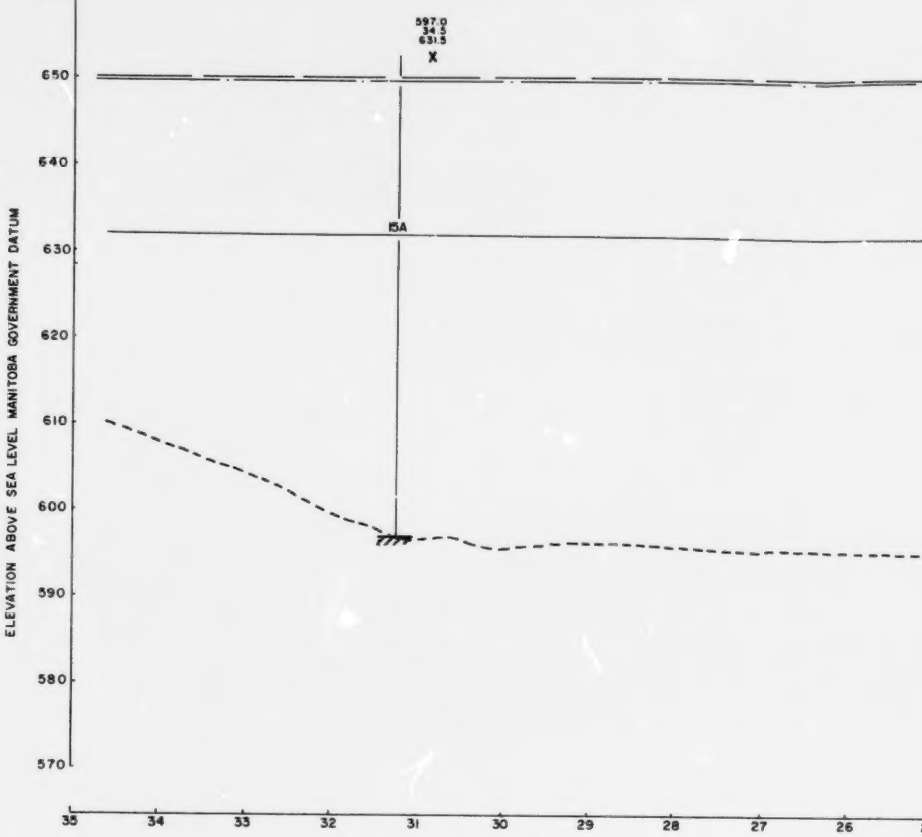
FIGURE 1

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

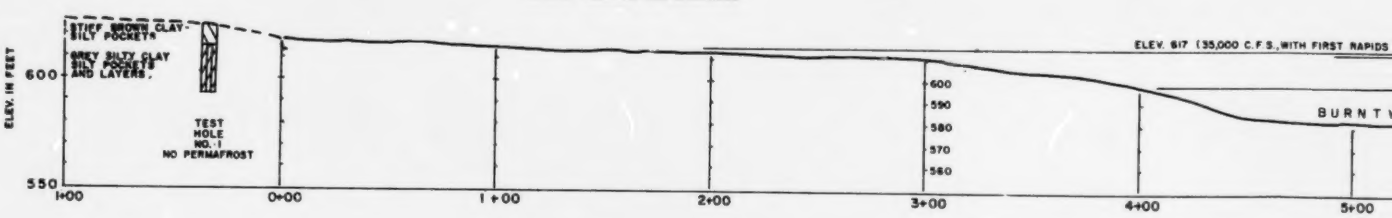
BURNTWOOD RIVER AT THOMPSON

EXTENT OF FLOODING,

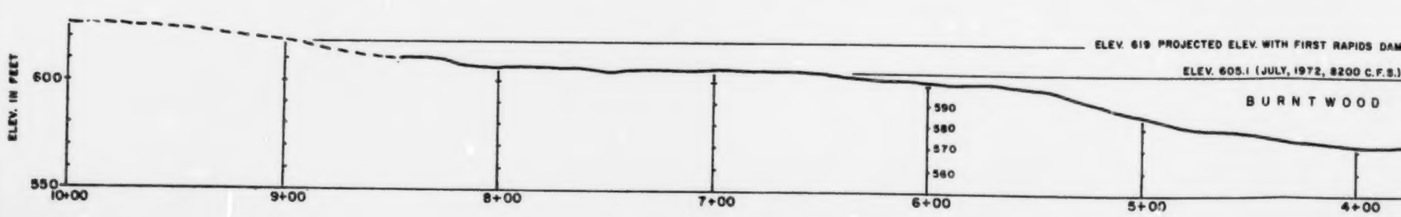
Q = 35,000 c.f.s.



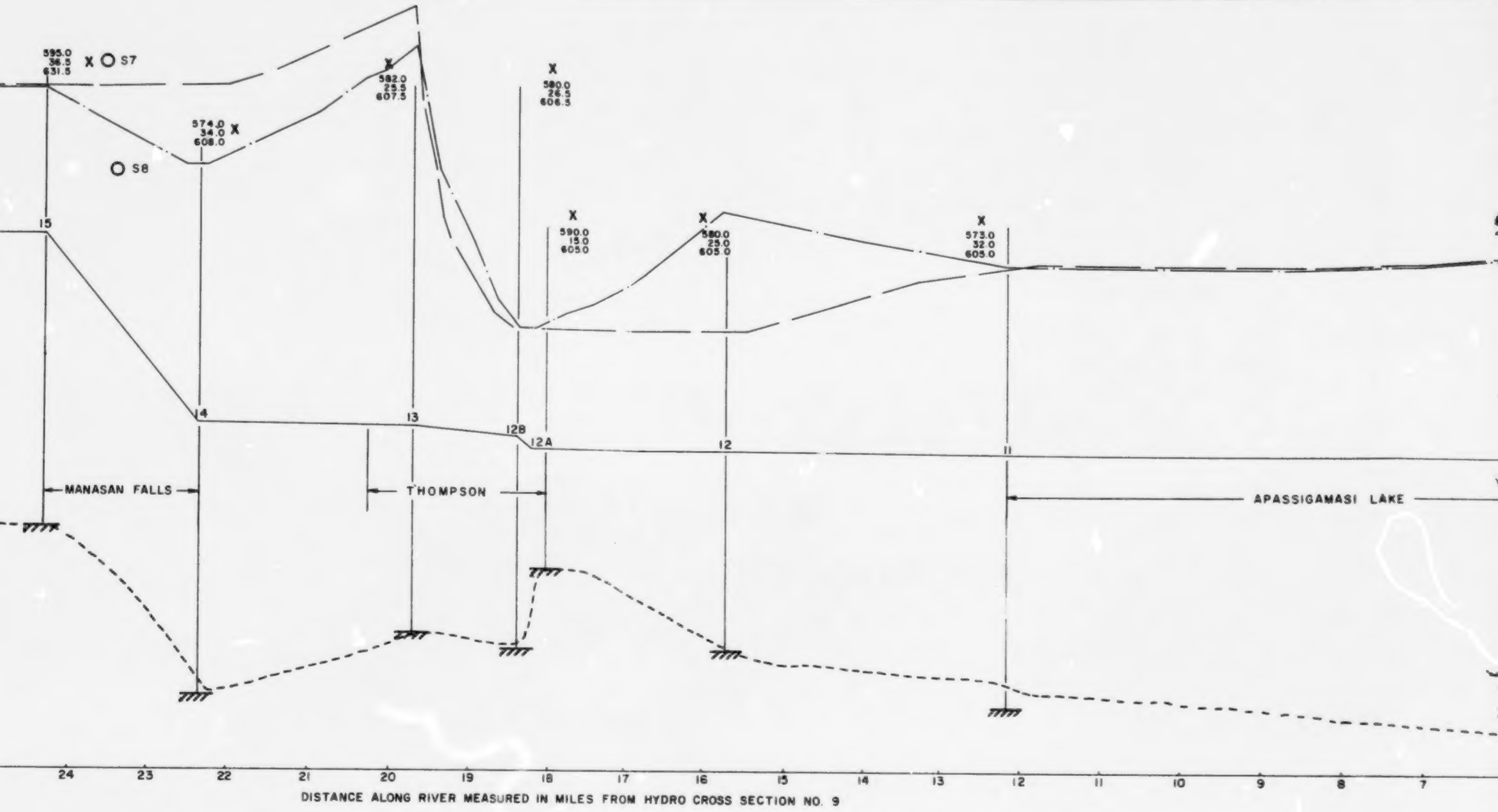
ELEVATION ABOVE SEA LEVEL MANITOBA GOVERNMENT DATUM
660
650
640
630
620
610
600
590
580
570
597.0
34.5
631.5
X
15A
35
34
33
32
31
30
29
28
27
26



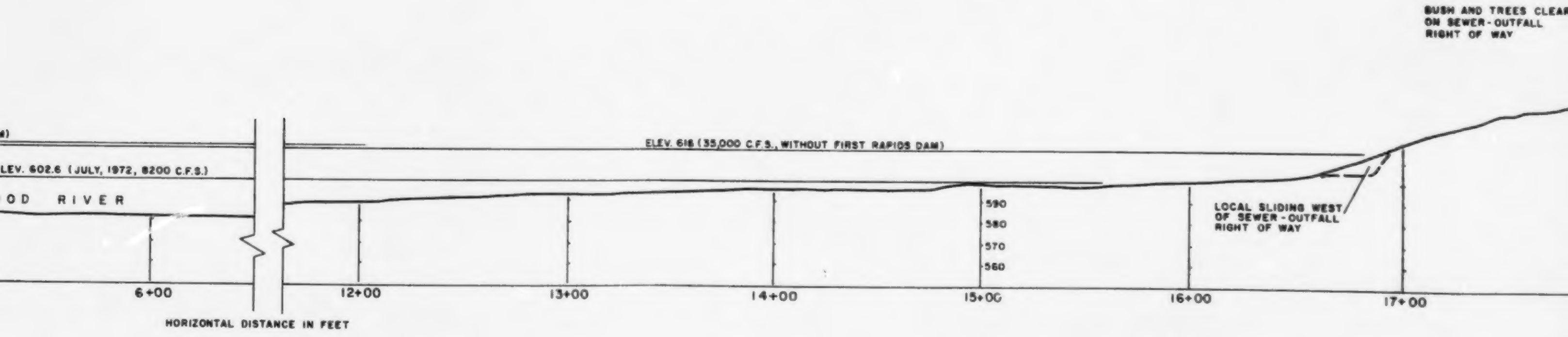
MOSTLY CLEARED AND GRAVELLED
STIFF BROWN CLAY-SILT POCKETS
GREY SILTY CLAY SILT POCKETS AND LAYERS.
TEST HOLE NO. 1 NO PERMAFROST
ELEV. 617 (35,000 C.F.S.,WITH FIRST RAPIDS
BURNT
ELEV. IN FEET
600
550
590
580
570
560
1+00
0+00
1+00
2+00
3+00
4+00
5+00



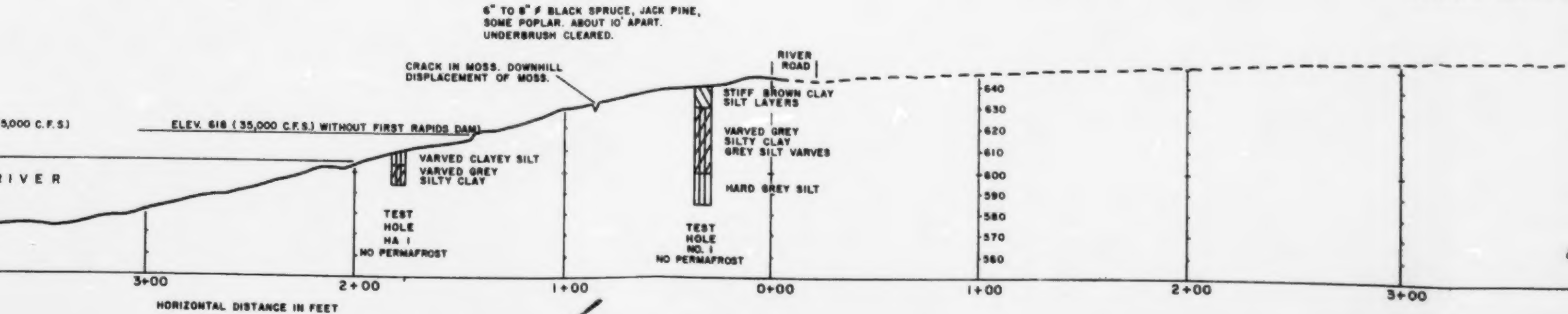
ELEV. 619 PROJECTED ELEV. WITH FIRST RAPIDS DAM
ELEV. 605.1 (JULY, 1972, 8200 C.F.S.)
BURNTWOOD
ELEV. IN FEET
600
550
590
580
570
560
10+00
9+00
8+00
7+00
6+00
5+00
4+00

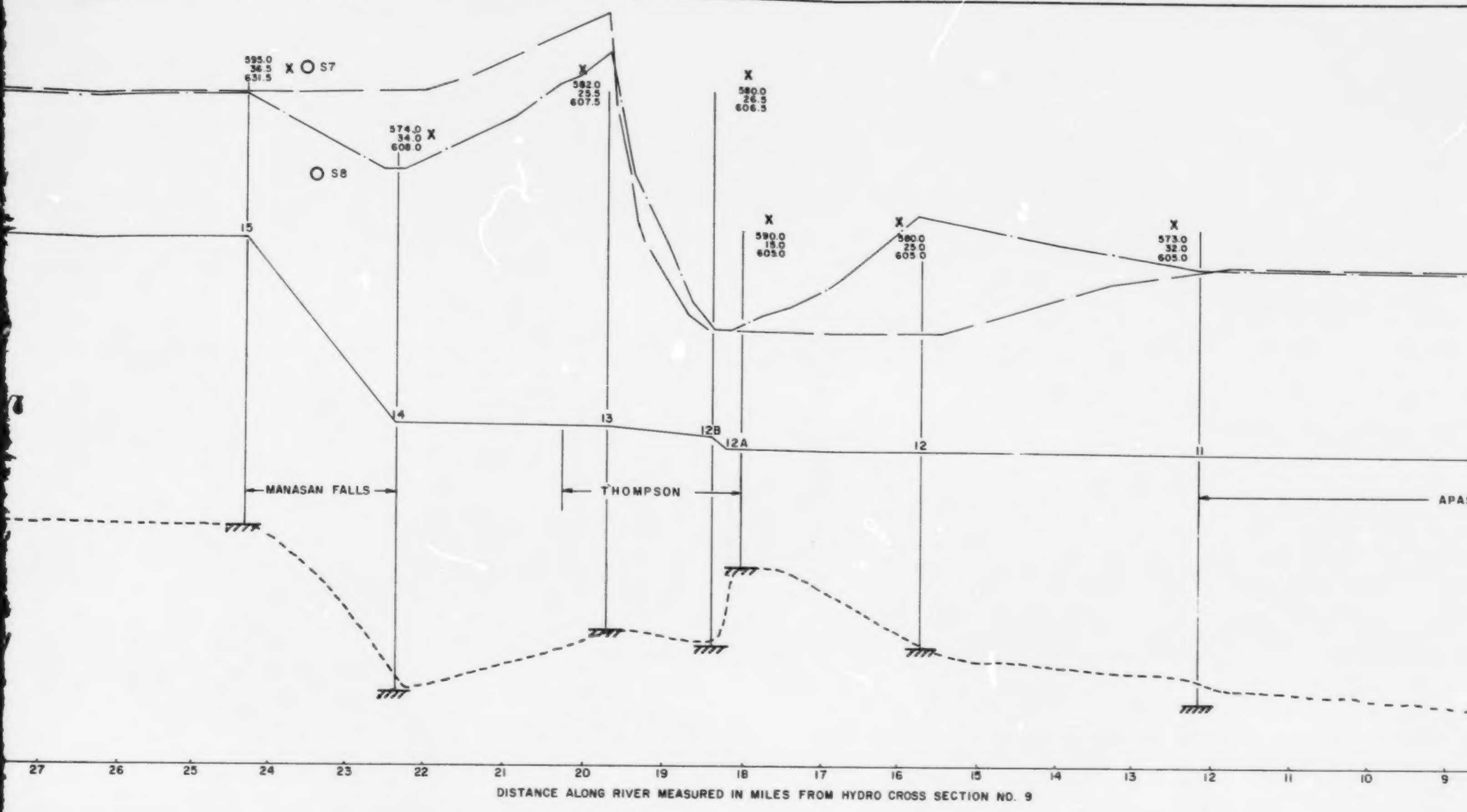


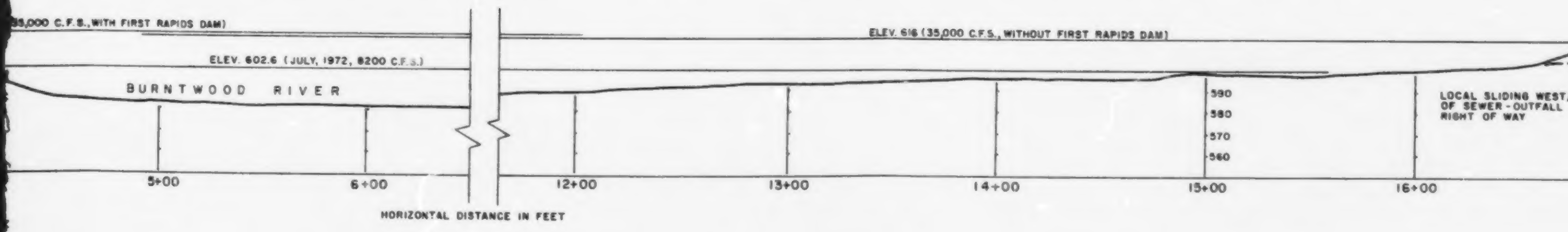
CROSS SECTI

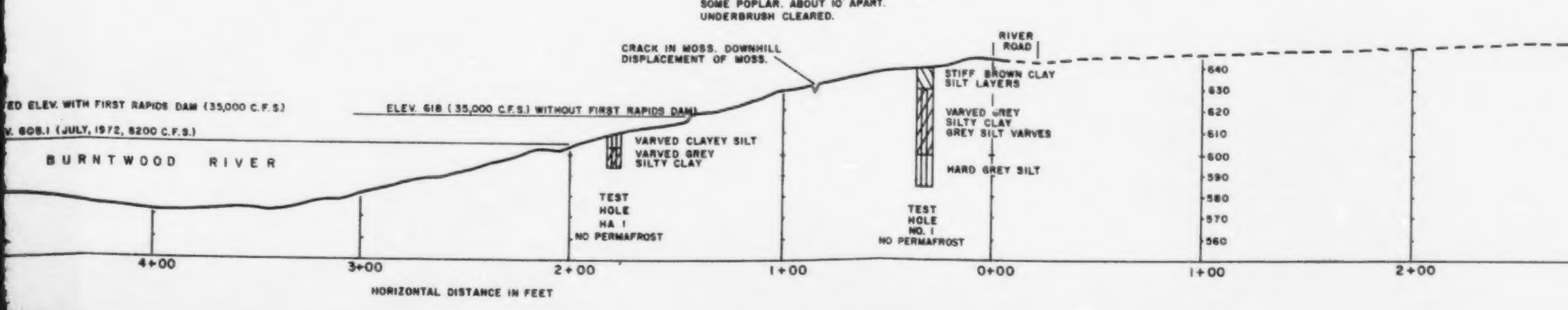

BUSH AND TREES CLEAR
ON SEWER-OUTFALL
RIGHT OF WAY
ELEV. 616 (35,000 C.F.S., WITHOUT FIRST RAPIDS DAM)
ELEV. 602.6 (JULY, 1972, 8200 C.F.S.)
OD RIVER
LOCAL SLIDING WEST OF SEWER-OUTFALL RIGHT OF WAY
590
580
570
560
6+00
12+00
13+00
14+00
15+00
16+00
17+00
HORIZONTAL DISTANCE IN FEET

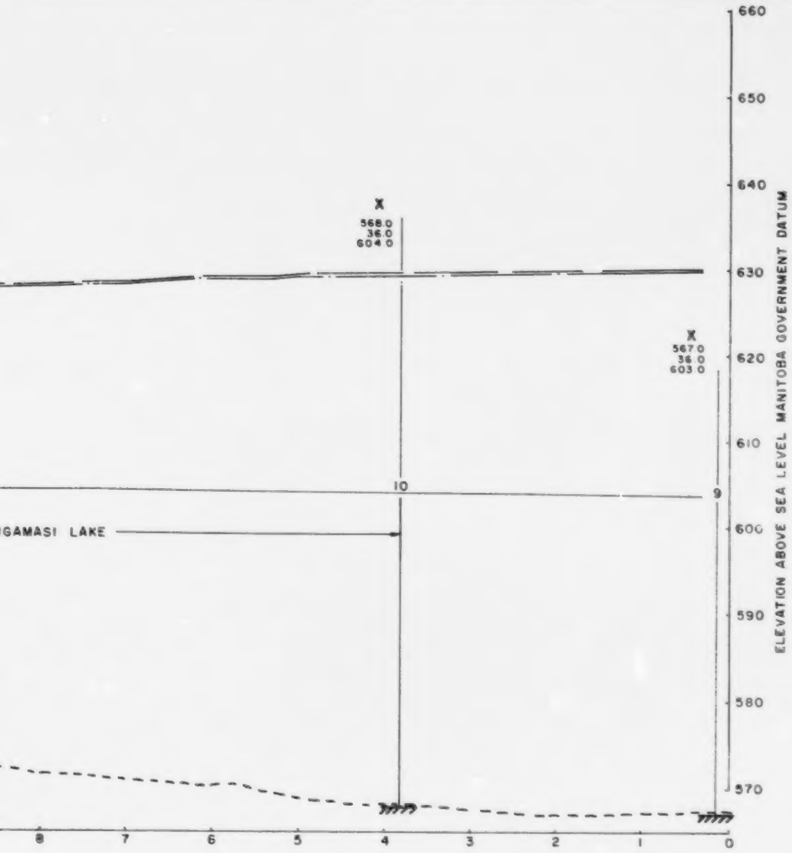
CROSS SECTI


6" TO 8" ∅ BLACK SPRUCE, JACK PINE,
SOME POPLAR. ABOUT 10' APART.
UNDERBRUSH CLEARED.
CRACK IN MOSS. DOWNHILL DISPLACEMENT OF MOSS.
RIVER ROAD
STIFF BROWN CLAY SILT LAYERS
VARVED GREY SILTY CLAY GREY SILT VARVES
HARD GREY SILT
5,000 C.F.S.)
ELEV. 618 (35,000 C.F.S.) WITHOUT FIRST RAPIDS DAM
RIVER
VARVED CLAYEY SILT
VARVED GREY SILTY CLAY
TEST HOLE HA 1
NO PERMAFROST
TEST HOLE NO. 1
NO PERMAFROST
640
630
620
610
600
590
580
570
560
3+00
2+00
1+00
0+00
1+00
2+00
3+00
HORIZONTAL DISTANCE IN FEET


595.0
36.5
631.5
X ○ S7
○ S8
574.0
34.0
608.0
X
592.0
25.5
607.5
X
580.0
26.5
606.5
X
590.0
15.0
605.0
X
580.0
25.0
605.0
X
573.0
32.0
605.0
15
14
13
12B
12A
12
11
MANASAN FALLS
THOMPSON
APA
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
DISTANCE ALONG RIVER MEASURED IN MILES FROM HYDRO CROSS SECTION NO. 9


35,000 C.F.S., WITH FIRST RAPIDS DAM)
ELEV. 616 (35,000 C.F.S., WITHOUT FIRST RAPIDS DAM)
ELEV. 602.6 (JULY, 1972, 8200 C.F.S.)
BURNTWOOD RIVER
590
580
570
560
LOCAL SLIDING WEST,
OF SEWER-OUTFALL
RIGHT OF WAY
5+00
6+00
12+00
13+00
14+00
15+00
16+00
HORIZONTAL DISTANCE IN FEET


6" TO 8" ⌀ BLACK SPRUCE, JACK PINE,
SOME POPLAR. ABOUT 10' APART.
UNDERBRUSH CLEARED.
CRACK IN MOSS. DOWNHILL
DISPLACEMENT OF MOSS.
RIVER
ROAD
STIFF BROWN CLAY
SILT LAYERS
VARVED GREY
SILTY CLAY
GREY SILT VARVES
HARD GREY SILT
ED ELEV. WITH FIRST RAPIDS DAM (35,000 C.F.S.)
ELEV. 618 (35,000 C.F.S.) WITHOUT FIRST RAPIDS DAM
V. 608.1 (JULY, 1972, 8200 C.F.S.)
BURNTWOOD RIVER
VARVED CLAYEY SILT
VARVED GREY
SILTY CLAY
TEST
HOLE
HA 1
NO PERMAFROST
TEST
HOLE
NO. 1
NO PERMAFROST
640
630
620
610
600
590
580
570
560
4+00
3+00
2+00
1+00
0+00
1+00
2+00
HORIZONTAL DISTANCE IN FEET



LEGEND

HYDRAULIC GRADIENT	————
BED ELEVATION	- - - - - - -
NORTH BANK ELEVATION	——— ———
SOUTH BANK ELEVATION	———·———
CROSS SECTION AVAILABLE	X
SEDIMENT METERING STATION	O

567.0	ELEVATION OF LOWEST POINT
36.0	MAXIMUM DEPTH
603.0	ELEVATION OF SURFACE WATER

NOTE

1. FOREBAY ELEVATION AT FIRST RAPIDS IS 610' CAUSING WATER LEVELS OF ELEVATION 619' AT THOMPSON.
2. FOREBAY ELEVATION AT MANASAN IS 690'.

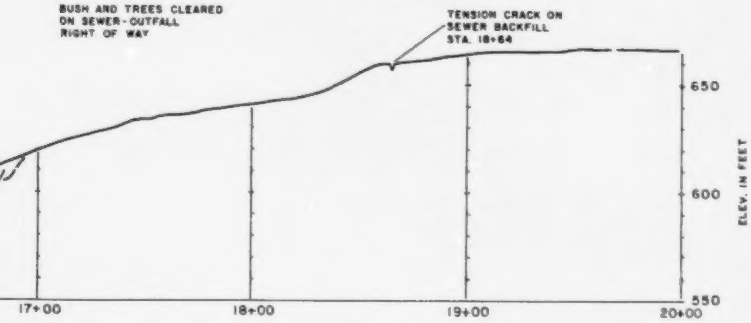
FIGURE 2

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

PROFILE
OF
BURNTWOOD RIVER

57-1-1006

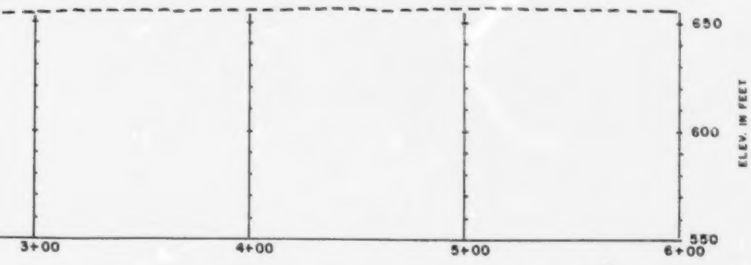
CROSS SECTION 1 LOOKING DOWNSTREAM


BUSH AND TREES CLEARED ON SEWER-OUTFALL RIGHT OF WAY
TENSION CRACK ON SEWER BACKFILL STA. 18+64
650
600
550
ELEV. IN FEET
17+00
18+00
19+00
20+00

LEGEND

▧	BROWN SILTY CLAY
▧	BROWN SILTY CLAY WITH SILT VARVES
▨	GREY VARVED CLAY
▥	GREY SANDY SILT
▩	BEDROCK
qu	UNCONFINED COMPRESSIVE STRENGTH (lb/Ft^2)
C	COHESION (lb/Ft^2)
ø	ANGLE OF INTERNAL FRICTION DEGREES
N	STANDARD PENETRATION BLOWS

CROSS SECTION 2 LOOKING DOWNSTREAM


650
600
550
ELEV. IN FEET
3+00
4+00
5+00
6+00

HORIZONTAL AND VERTICAL SCALES 1" = 40'

GEODETIC SURVEYS OF CANADA ELEVATIONS

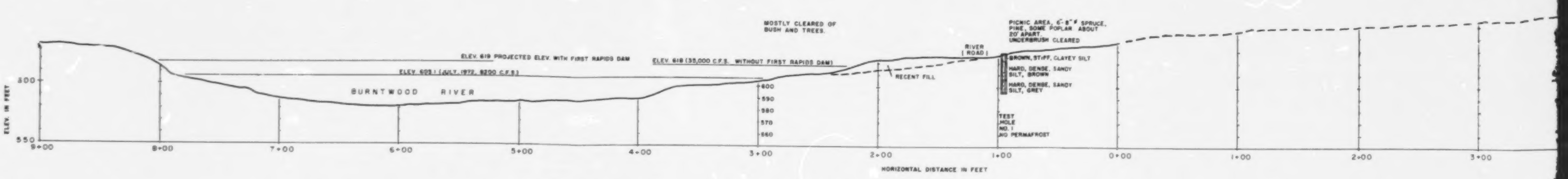
FIGURE 3a

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

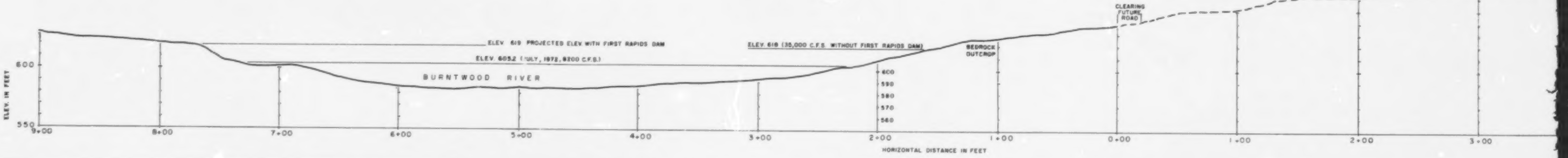
BURNTWOOD RIVER AT THOMPSON

CROSS SECTIONS 1 & 2

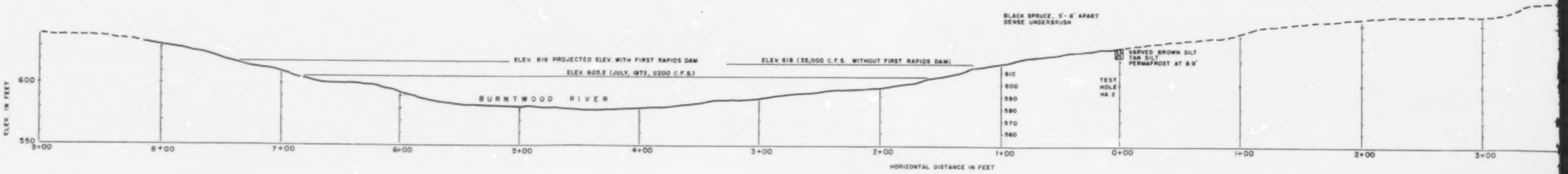
CROSS SEC


MOSTLY CLEARED OF
BUSH AND TREES.
PICNIC AREA, 6"-8" ⌀ SPRUCE,
PINE, SOME POPLAR ABOUT
20' APART.
UNDERBRUSH CLEARED
ELEV. 619 PROJECTED ELEV. WITH FIRST RAPIDS DAM
ELEV. 618 (35,000 C.F.S. WITHOUT FIRST RAPIDS DAM)
ELEV. 605.1 (JULY, 1972, 9200 C.F.S.)
RIVER
(ROAD)
BROWN, STIFF, CLAYEY SILT
HARD, DENSE, SANDY
SILT, BROWN
HARD, DENSE, SANDY
SILT, GREY
RECENT FILL
BURNTWOOD RIVER
TEST
HOLE
NO. 1
NO PERMAFROST
ELEV. IN FEET
600
550
600
590
580
570
560
9+00
8+00
7+00
6+00
5+00
4+00
3+00
2+00
1+00
0+00
1+00
2+00
3+00
HORIZONTAL DISTANCE IN FEET

CROSS SECT

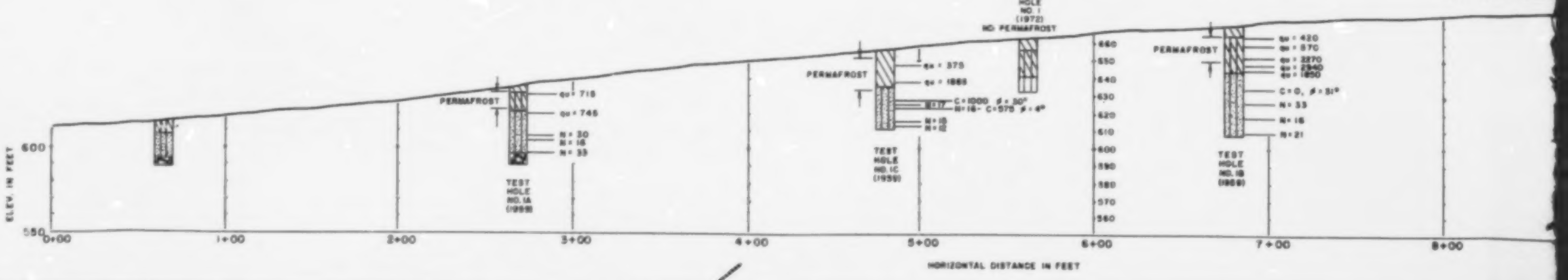

CLEARING
FUTURE
ROAD
ELEV. 619 PROJECTED ELEV. WITH FIRST RAPIDS DAM
ELEV. 618 (35,000 C.F.S. WITHOUT FIRST RAPIDS DAM)
ELEV. 605.2 (JULY, 1972, 9200 C.F.S.)
BEDROCK
OUTCROP
BURNTWOOD RIVER
ELEV. IN FEET
600
550
600
590
580
570
560
9+00
8+00
7+00
6+00
5+00
4+00
3+00
2+00
1+00
0+00
1+00
2+00
3+00
HORIZONTAL DISTANCE IN FEET

CROSS SEC

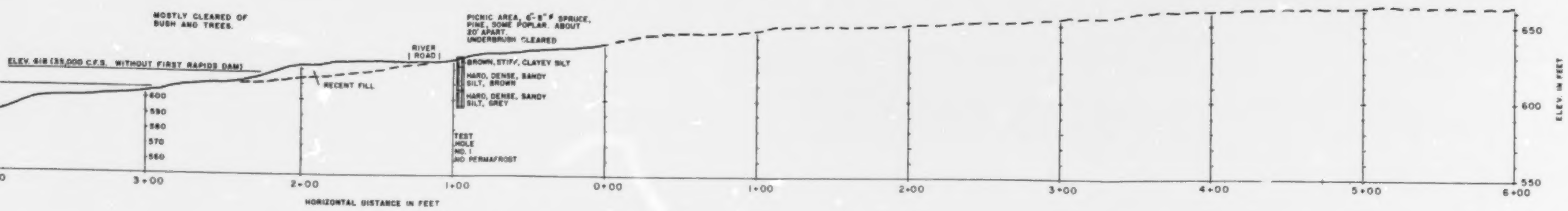

BLACK SPRUCE, 5'-6' APART
DENSE UNDERBRUSH
ELEV. 619 PROJECTED ELEV. WITH FIRST RAPIDS DAM
ELEV. 618 (35,000 C.F.S. WITHOUT FIRST RAPIDS DAM)
ELEV. 605.2 (JULY, 1972, 9200 C.F.S.)
VARVED BROWN SILT
TAN SILT
PERMAFROST AT 8.9'
TEST
HOLE
HA 2
BURNTWOOD RIVER
ELEV. IN FEET
600
550
610
600
590
580
570
560
9+00
8+00
7+00
6+00
5+00
4+00
3+00
2+00
1+00
0+00
1+00
2+00
3+00
HORIZONTAL DISTANCE IN FEET

CROSS SEC

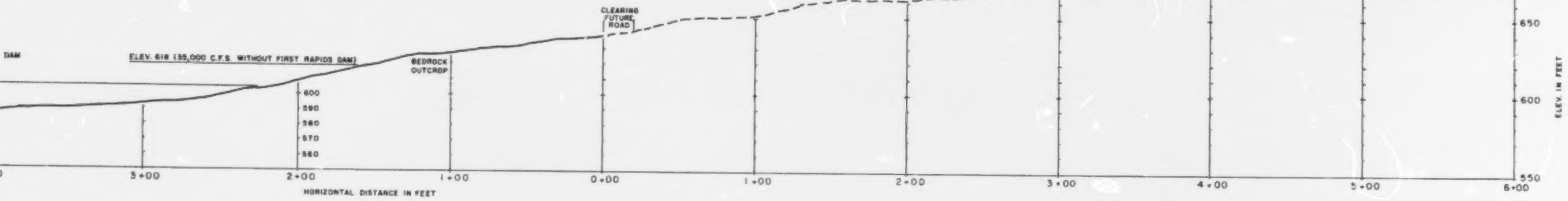
NOTE:
CROSS SECTION 6 FROM 1959 REPORT BY
BARACOS AND MARANTZ. PREPARED FOR
INTERNATIONAL NICKEL CO. LTD.


PERMAFROST
qu = 718
qu = 745
N = 30
N = 16
N = 33
TEST
HOLE
NO. 1A
(1959)
PERMAFROST
qu = 373
qu = 1868
C = 1000 ⌀ = 30°
N = 16 - C = 575 ⌀ = 4°
N = 15
N = 12
TEST
HOLE
NO. 1C
(1959)
TEST
HOLE
NO. 1
(1972)
NO PERMAFROST
PERMAFROST
qu = 420
qu = 570
qu = 2270
qu = 2940
qu = 1850
C = 0, ⌀ = 31°
N = 33
N = 16
N = 21
TEST
HOLE
NO. 1B
(1959)
ELEV. IN FEET
600
550
660
650
640
630
620
610
600
590
580
570
560
0+00
1+00
2+00
3+00
4+00
5+00
6+00
7+00
8+00
HORIZONTAL DISTANCE IN FEET

CROSS SECTION 3 LOOKING DOWNSTREAM


MOSTLY CLEARED OF BUSH AND TREES.
PICNIC AREA, 6"-8" ø SPRUCE, PINE, SOME POPLAR. ABOUT 20' APART. UNDERBRUSH CLEARED
RIVER (ROAD)
ELEV. 618 (35,000 C.F.S. WITHOUT FIRST RAPIDS DAM)
RECENT FILL
BROWN, STIFF, CLAYEY SILT
HARD, DENSE, SANDY SILT, BROWN
HARD, DENSE, SANDY SILT, GREY
TEST HOLE NO. 1 NO PERMAFROST
600
590
580
570
560
650
600
550
ELEV. IN FEET
3+00
2+00
1+00
0+00
1+00
2+00
3+00
4+00
5+00
6+00
HORIZONTAL DISTANCE IN FEET

CROSS SECTION 4 LOOKING DOWNSTREAM


DAM
ELEV. 618 (35,000 C.F.S. WITHOUT FIRST RAPIDS DAM)
BEDROCK OUTCROP
CLEARING FUTURE ROAD
600
590
580
570
560
650
600
550
ELEV. IN FEET
3+00
2+00
1+00
0+00
1+00
2+00
3+00
4+00
5+00
6+00
HORIZONTAL DISTANCE IN FEET

LEGEND

- ▧ BROWN SILTY CLAY
- ▧ BROWN SILTY CLAY WITH SILT VARVES
- ▧ GREY VARVED CLAY
- ▥ GREY SANDY SILT
- ▨ BEDROCK

qu UNCONFINED COMPRESSIVE STRENGTH (lb/Ft²)
C COHESION (lb/Ft²)
ø ANGLE OF INTERNAL FRICTION DEGREES
N STANDARD PENETRATION BLOWS

HORIZONTAL AND VERTICAL SCALES 1" = 40'
GEODETIC SURVEYS OF CANADA ELEVATIONS

FIGURE 3b

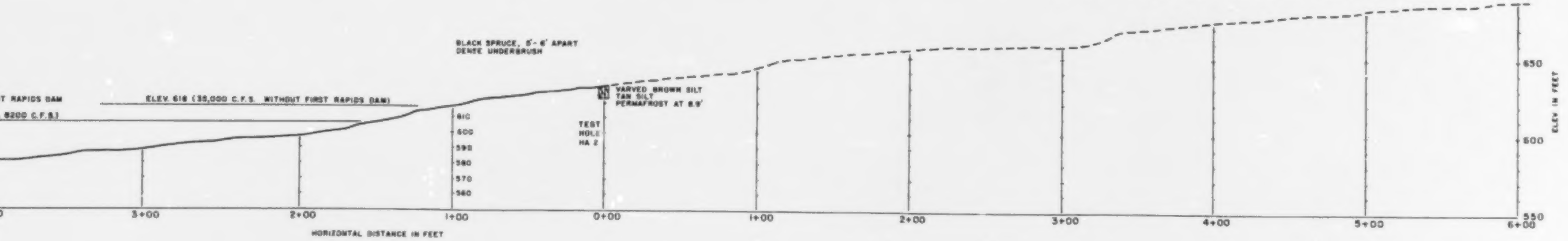
PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

BURNTWOOD RIVER AT THOMPSON

CROSS SECTIONS 3 & 4

57-1-1006

CROSS SECTION 5 LOOKING DOWNSTREAM

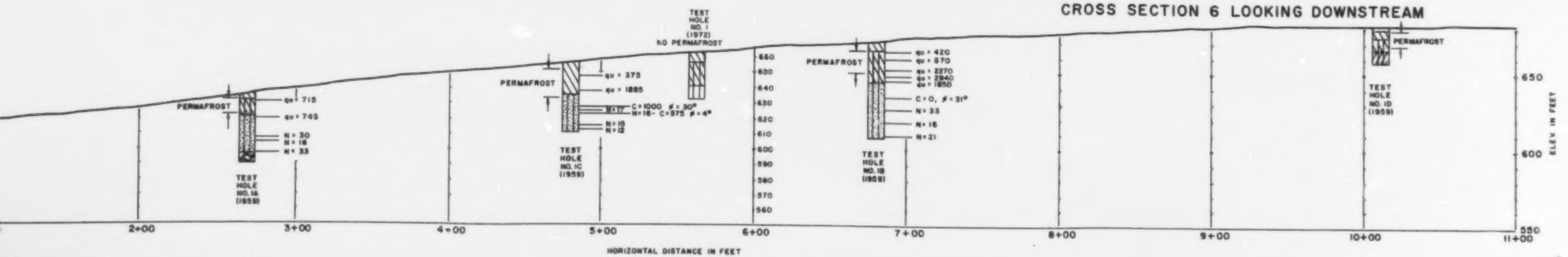

BLACK SPRUCE, 5'-6' APART DENSE UNDERBRUSH
T RAPIDS DAM
8200 C.F.S.)
ELEV. 618 (35,000 C.F.S. WITHOUT FIRST RAPIDS DAM)
VARVED BROWN SILT TAN SILT PERMAFROST AT 8.9'
TEST HOLE HA 2
610
600
590
580
570
560
650
600
550
ELEV. IN FEET
3+00
2+00
1+00
0+00
1+00
2+00
3+00
4+00
5+00
6+00
HORIZONTAL DISTANCE IN FEET

LEGEND

- ▧ BROWN SILTY CLAY
- ▧ BROWN SILTY CLAY WITH SILT VARVES
- ▧ GREY VARVED CLAY
- ▥ GREY SANDY SILT
- ▨ BEDROCK

qu UNCONFINED COMPRESSIVE STRENGTH (lb/Ft²)
C COHESION (lb/Ft²)
ø ANGLE OF INTERNAL FRICTION DEGREES
N STANDARD PENETRATION BLOWS

CROSS SECTION 6 LOOKING DOWNSTREAM


PERMAFROST
qu = 715
qu = 745
N = 30
N = 18
N = 33
TEST HOLE NO. 1A (1959)
PERMAFROST
qu = 375
qu = 1885
N = 17
C = 1000 ø = 30°
N = 16 - C = 575 ø = 4°
N = 15
N = 12
TEST HOLE NO. 1C (1959)
TEST HOLE NO. 1 (1972) NO PERMAFROST
PERMAFROST
qu = 420
qu = 570
qu = 2270
qu = 2940
qu = 1850
C = 0, ø = 31°
N = 33
N = 16
N = 21
TEST HOLE NO. 1B (1959)
PERMAFROST
TEST HOLE NO. 1D (1959)
660
650
640
630
620
610
600
590
580
570
560
650
600
550
ELEV. IN FEET
2+00
3+00
4+00
5+00
6+00
7+00
8+00
9+00
10+00
11+00
HORIZONTAL DISTANCE IN FEET

HORIZONTAL AND VERTICAL SCALES 1" = 40'
GEODETIC SURVEYS OF CANADA ELEVATIONS

FIGURE 3c

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

BURNTWOOD RIVER AT THOMPSON

CROSS SECTIONS 5 & 6

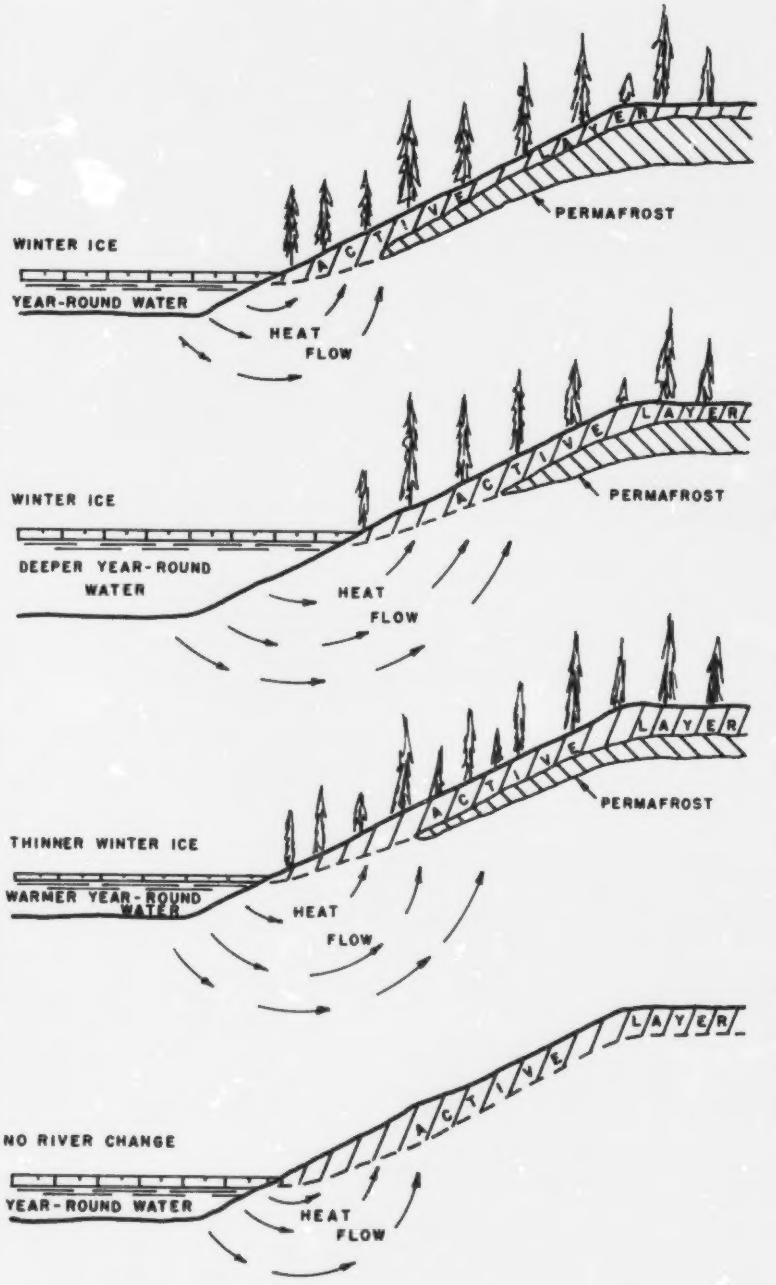

WINTER ICE
YEAR-ROUND WATER
HEAT FLOW
ACTIVE LAYER
PERMAFROST
WINTER ICE
DEEPER YEAR-ROUND WATER
HEAT FLOW
ACTIVE LAYER
PERMAFROST
THINNER WINTER ICE
WARMER YEAR-ROUND WATER
HEAT FLOW
ACTIVE LAYER
PERMAFROST
NO RIVER CHANGE
YEAR-ROUND WATER
HEAT FLOW
ACTIVE LAYER

FIGURE 4a

PERMAFROST ON SIMPLE SLOPE
NOTE PERMAFROST TAPERING TOWARDS RIVER.

FIGURE 4b

EFFECT OF RAISED RIVER LEVEL ON PERMAFROST
NOTE RECESSION OF PERMAFROST TAPER UP SLOPE.

FIGURE 4c

EFFECT OF WARMER YEAR-ROUND RIVER WATER
NOTE RECESSION AND THINNING FROM BOTTOM OF PERMAFROST.

FIGURE 4d

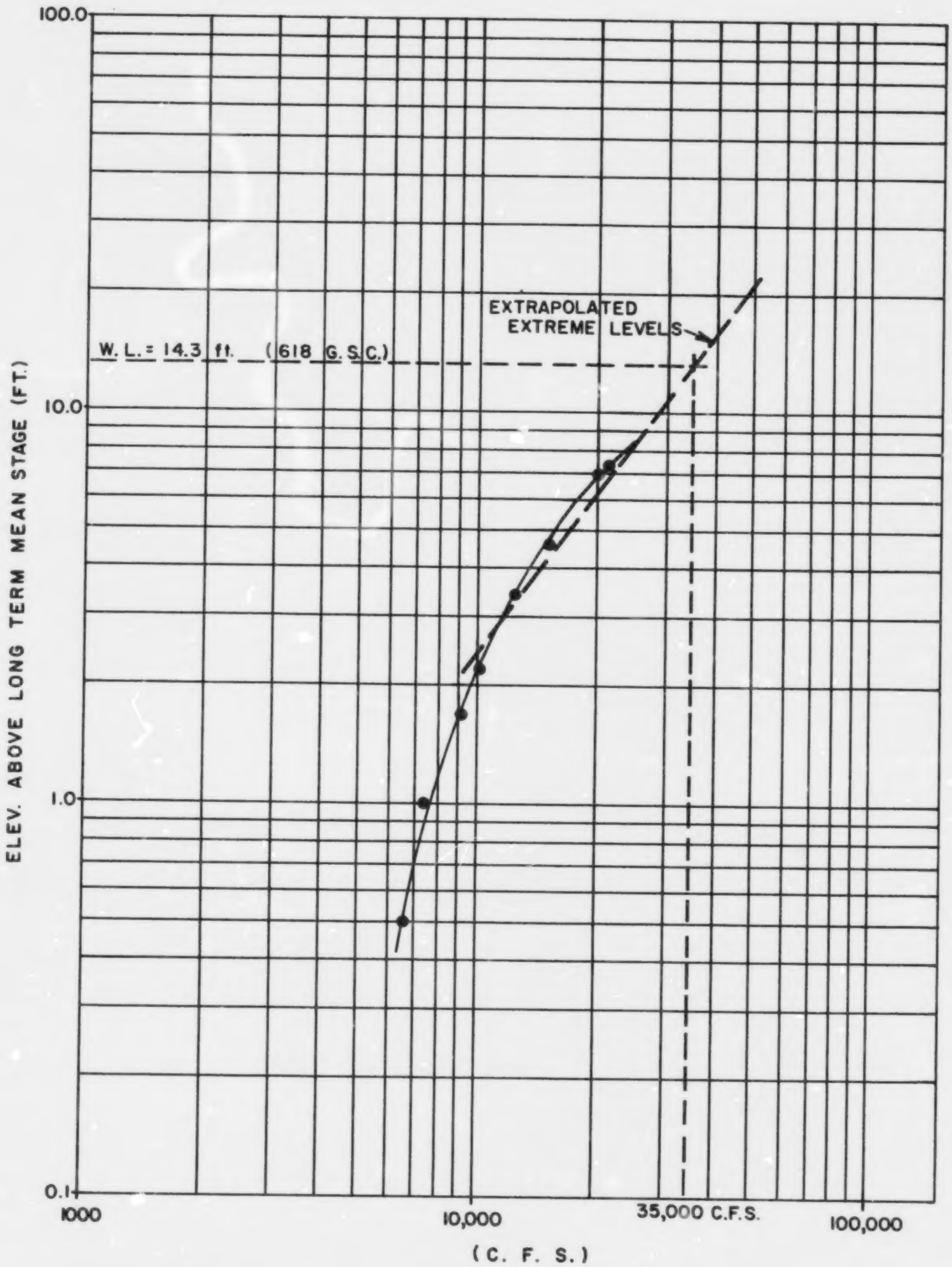
EFFECT OF REMOVAL OF TREES, UNDERBRUSH AND MOSS COVER.
NOTE ELIMINATION OF PERMAFROST AND THICKENNING OF ACTIVE LAYER.

FIGURE 4

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

BURNTWOOD RIVER AT THOMPSON
CHANGES IN RIVER BANK PERMAFROST INDUCED BY RAISED RIVER LEVEL, WARMER FLOW, OR REMOVAL OF VEGETATION COVER.

57-1-1006



LONG TERM MEAN FLOW = 5800 C. F. S.
LONG TERM MEAN STAGE = 603.7 FT. (G.S.C.)

FIGURE 5

SOURCE – WATER SURVEY
OF CANADA

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

BURNTWOOD RIVER AT THOMPSON
STAGE DISCHARGE RELATIONSHIP AT PUMPHOUSE

57-1-1006

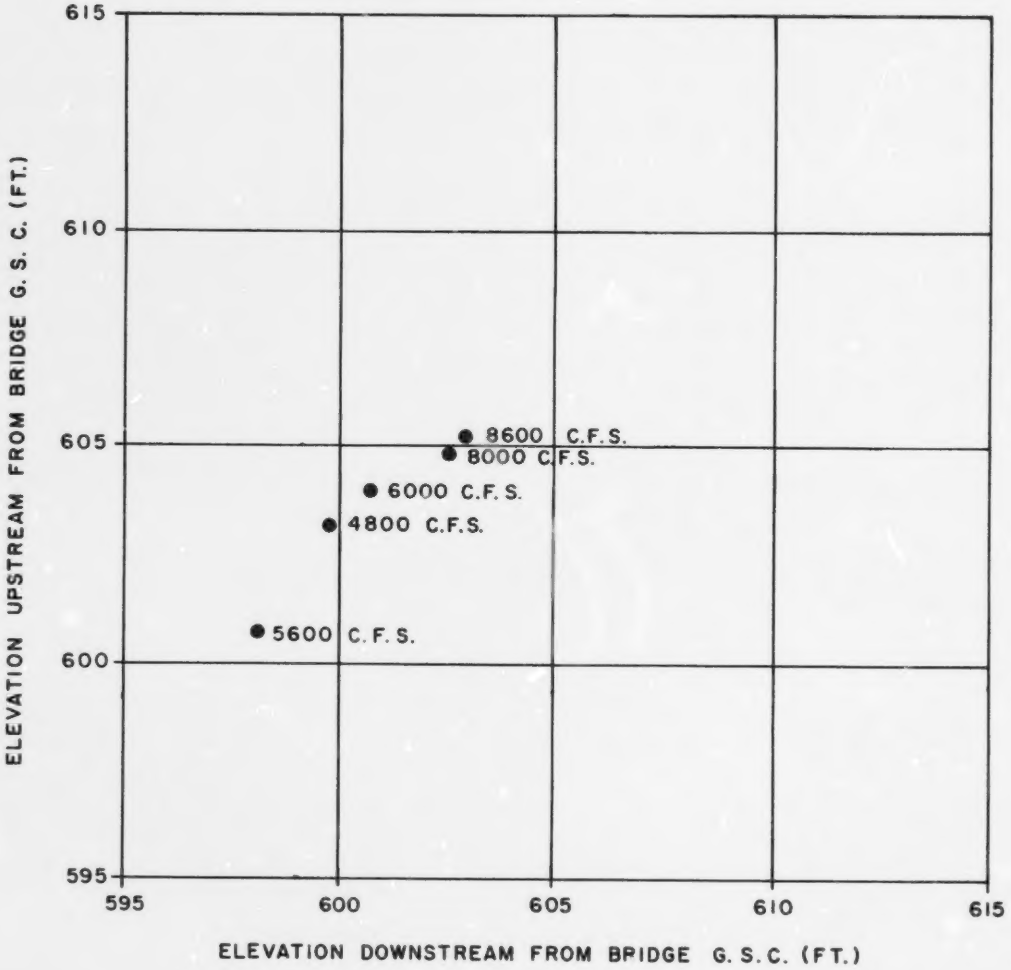


FIGURE 6

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

BURNTWOOD RIVER AT THOMPSON
PLOT OF UPSTREAM STAGE AGAINST DOWNSTREAM STAGE

57-1-1006

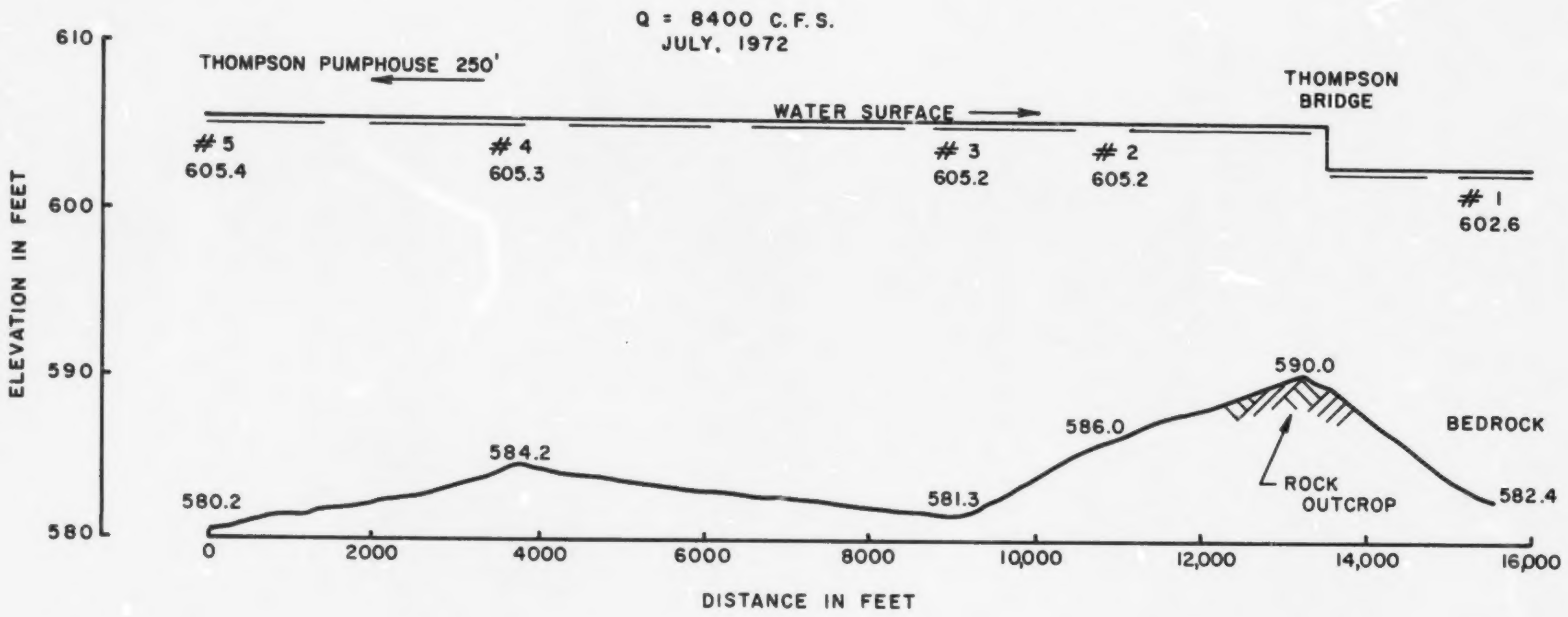


FIGURE 7

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

BURNTWOOD RIVER AT THOMPSON

LOCAL WATER SURFACE PROFILE

57-1-1006

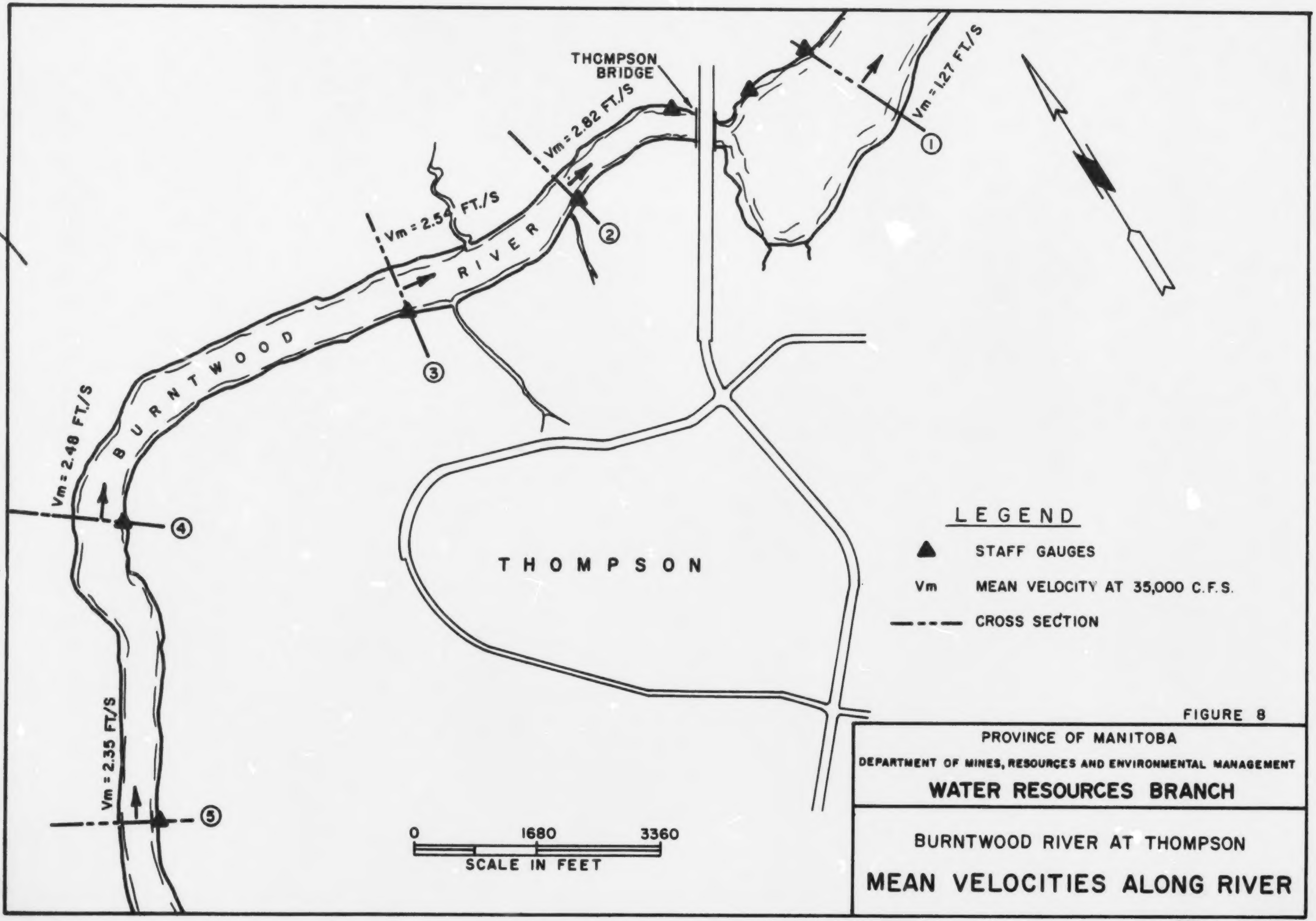

THOMPSON BRIDGE
Vm = 1.27 FT./S
①
Vm = 2.82 FT./S
②
Vm = 2.54 FT./S
③
Vm = 2.48 FT./S
④
Vm = 2.35 FT./S
⑤
BURNTWOOD RIVER
THOMPSON
LEGEND
▲ STAFF GAUGES
Vm MEAN VELOCITY AT 35,000 C.F.S.
— - - — CROSS SECTION
0
1680
3360
SCALE IN FEET

FIGURE 8

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

BURNTWOOD RIVER AT THOMPSON

MEAN VELOCITIES ALONG RIVER

57-1-1006

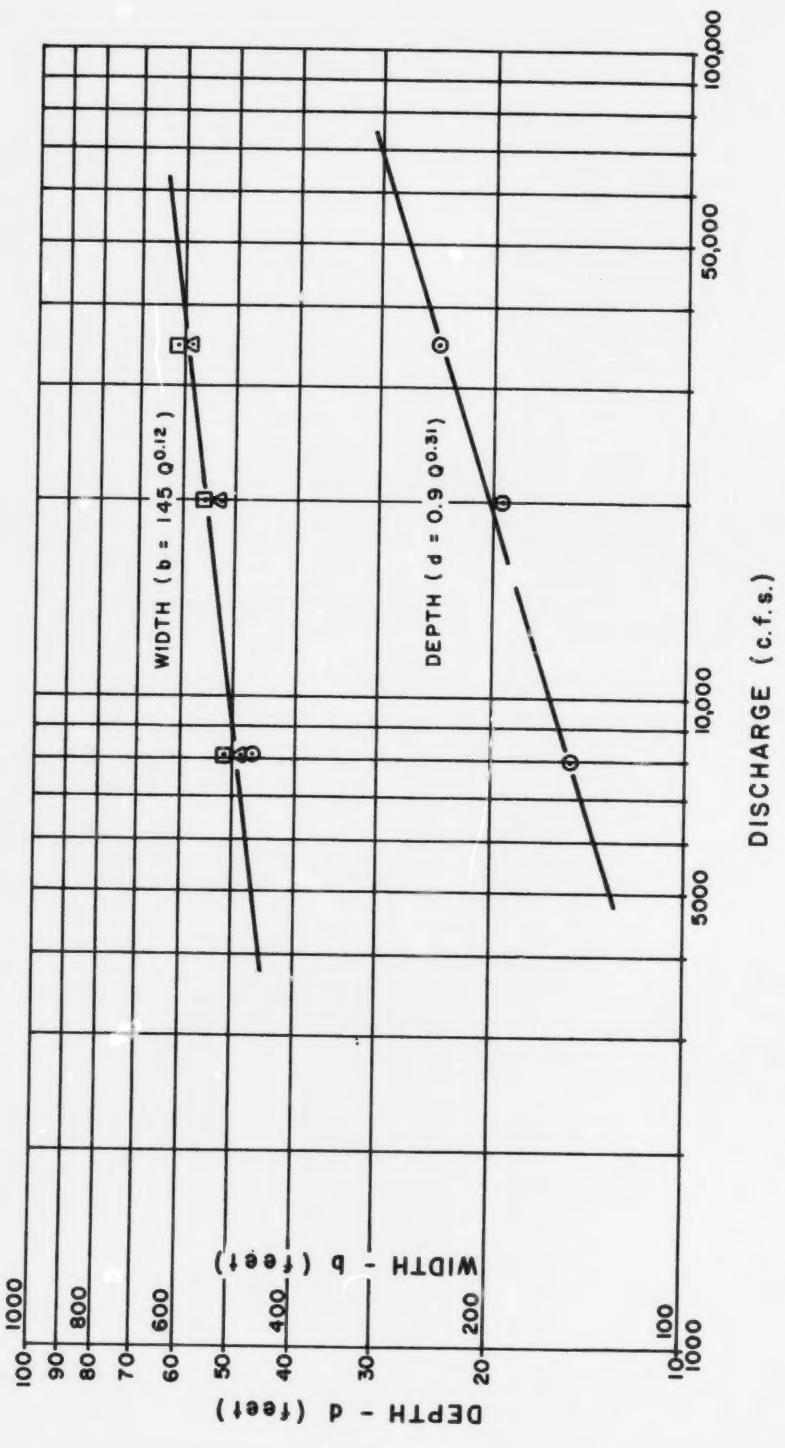


FIGURE 9

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

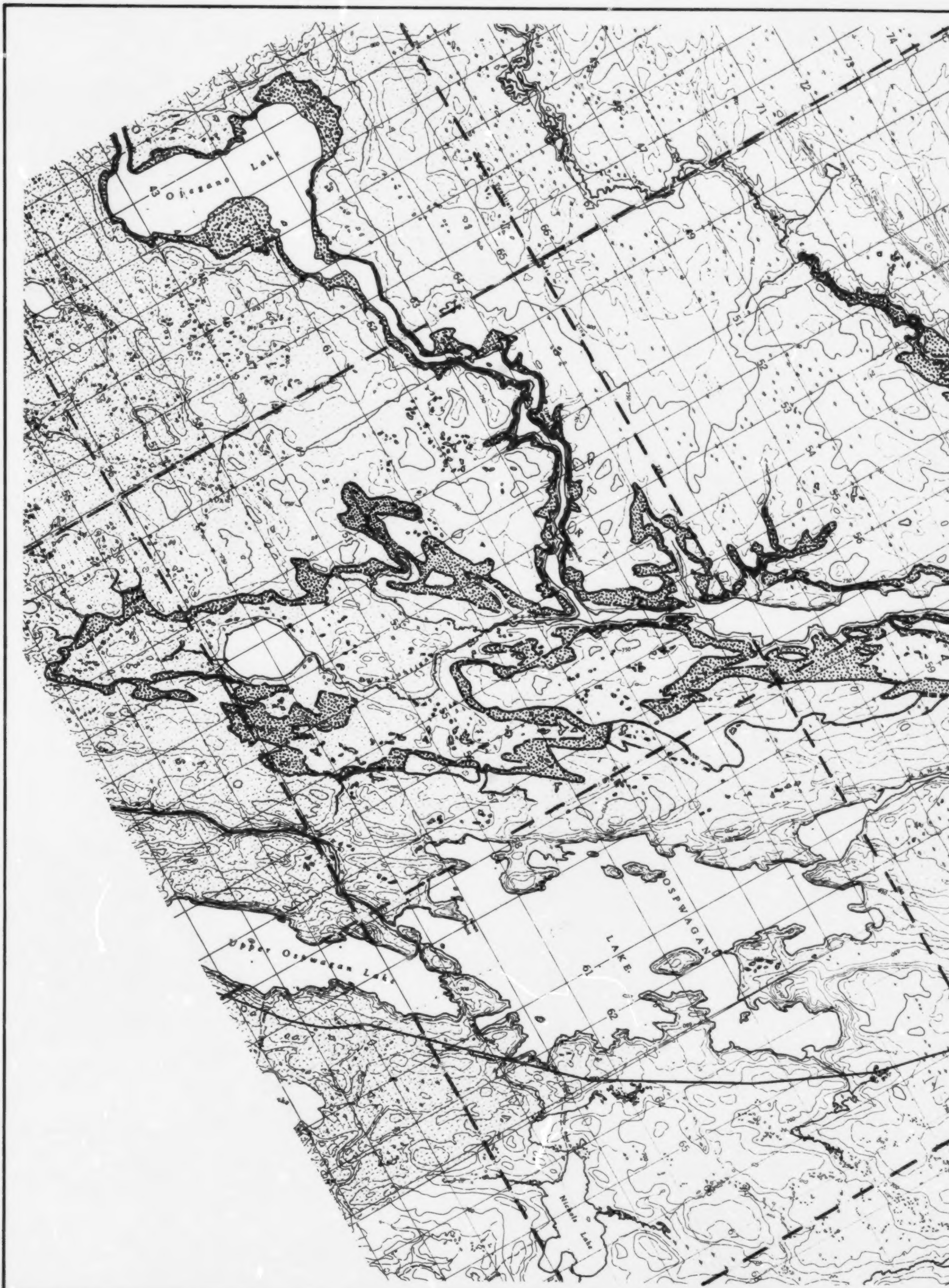
BURNTWOOD RIVER AT THOMPSON

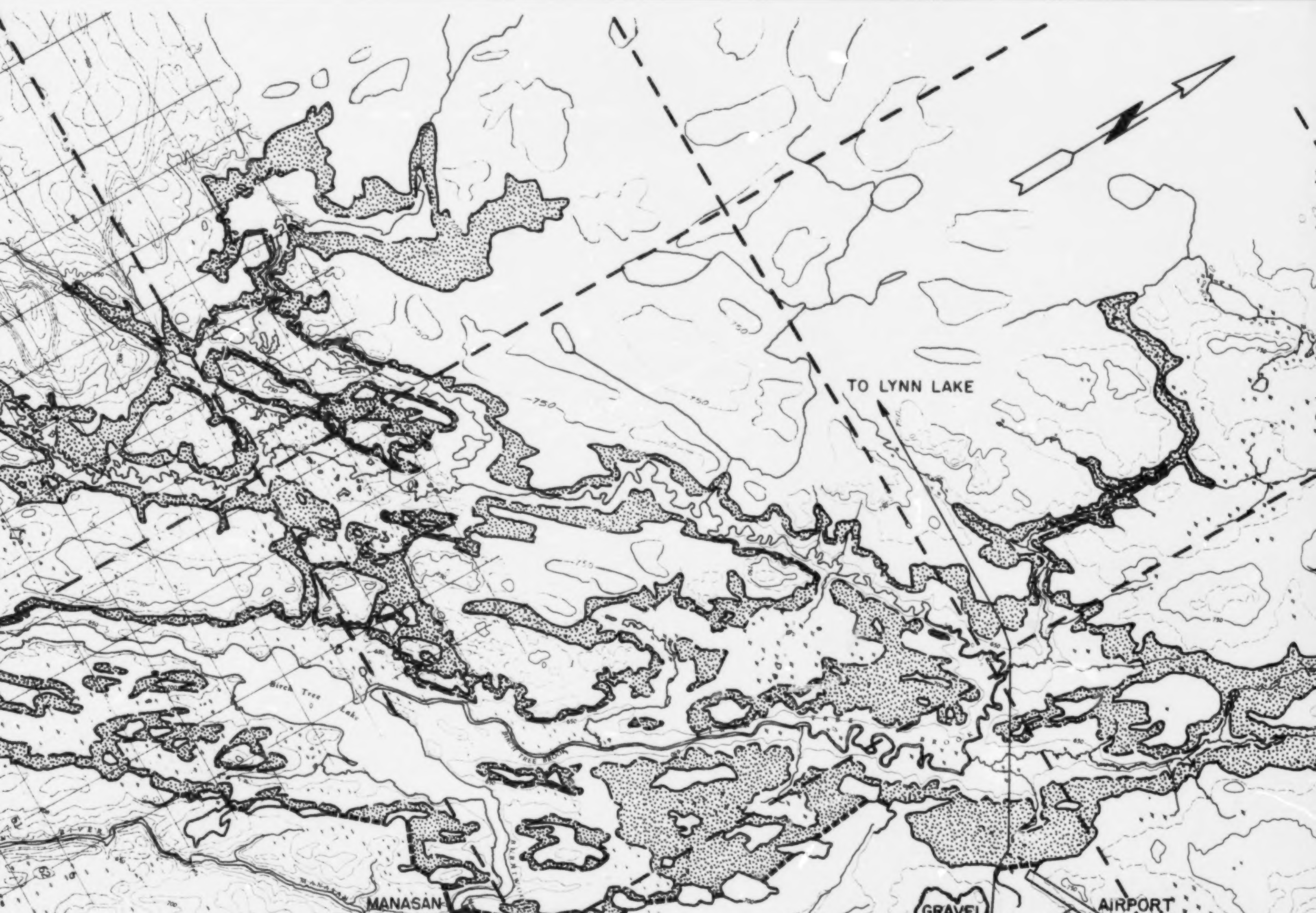
CHANNEL CHARACTERISTICS AT PUMPHOUSE

57-1-1006

APPENDIX 4 - F

ANTICIPATED EFFECTS OF RAISED LAKE LEVELS ON SHORELINES AT NELSON HOUSE, MANITOBA


Opegano Lake
Upper Ospwagan Lake
OSPWAGAN LAKE
Nickels Lake


TO LYNN LAKE
N
Birch Tree Lake
MANASAN DAM
GRAVEL HILL
AIRPORT
THOMPSON
RIVER
BURNTWOOD
0
2
SCALE IN MILES

PROVINCE
DEPARTMENT OF MINES, RESOURC
WATER RESO

BURNTWOOD RIV
POSSIBLE EXTENT
CONSTRUCTION

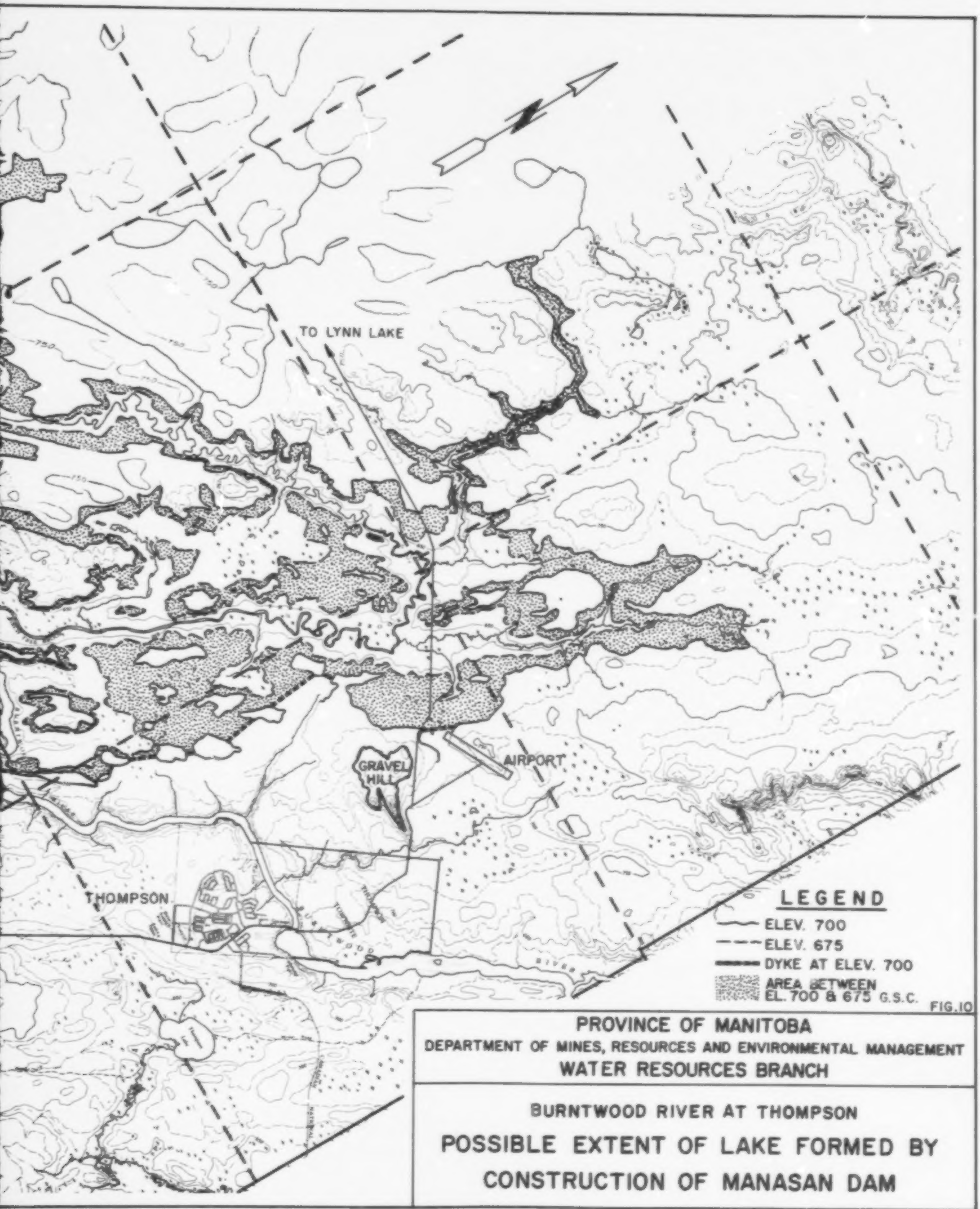

TO LYNN LAKE
750
GRAVEL HILL
AIRPORT
THOMPSON
BURNTWOOD
RIVER
LEGEND
ELEV. 700
ELEV. 675
DYKE AT ELEV. 700
AREA BETWEEN EL. 700 & 675 G.S.C.

FIG. 10

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

BURNTWOOD RIVER AT THOMPSON

POSSIBLE EXTENT OF LAKE FORMED BY CONSTRUCTION OF MANASAN DAM

ANTICIPATED EFFECTS
OF RAISED LAKE LEVELS ON SHORELINES
AT NELSON HOUSE, MANITOBA

by

A. BARACOS and V. GALAY
Department of Civil Engineering
University of Manitoba
Winnipeg, Manitoba
August, 1973

sub-contracted by:

Water Resources Branch
Manitoba Department of Mines, Resources and Environmental Management
Winnipeg, Manitoba

for

THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SPECIAL NOTE

THE CONCLUSIONS AND RECOMMENDATIONS CONTAINED IN THIS APPENDIX ARE THOSE OF THE AUTHOR(S) AND ARE NOT NECESSARILY THE SAME AS THE CONCLUSIONS AND RECOMMENDATIONS OF THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD AS EXPRESSED IN THE SUMMARY REPORT AND THE TECHNICAL REPORT.

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Scope of Study.. 3

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3	Bank susceptible to wave erosion with raised water level. Light building will have to be raised to higher ground....	15
4	One of three large cemeteries located at the top of the bank. A rock ledge at the toe of the bank can support rip-rap protection.......................................	15
5	The lower portion of this bank is currently unstable. Buildings on top are well above raised water levels.......	16
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Cross-Section No. 10, 11, & 12	5-4
Cross-Section No. 13 & 14	5-5

ABSTRACT

Raising of Footprint Lake from elevation approximately 783 to 806, or possibly to 810, will make an island of part of Nelson House community, will cut local unimproved roads in three locations, and will cut the road from Thompson at two locations. Raising of grades and/or relocation of roads will be necessary to maintain present communication. Advantage can be taken of possible relocation to better locate roads. The higher lake elevation will result in the formation of several islands and increase the available shore length permitting more shoreline locations for houses. The majority of buildings are on high ground. Only 3 or 4 houses will require relocation. New wharfs for small boats and relatively light pumphouses can readily be located on high ground. Trees will require cutting to give shorelines comparable to existing shorelines.

Certain banks will undergo erosion primarily due to wave action and this process is discussed. The erosion can lead to subsequent sliding unless protective measures are taken. In most cases, the protection can wait until experience indicates where and when, erosion is most likely to develop. Rip-rap can be used to protect against erosion. Areas requiring fairly early decisions regarding protection include: the bank adjacent to the airstrip, several areas near buildings and four cemetery locations.

If the banks are subject to rapid draw-down of lake level, sliding will likely take place at a number of locations where present stability is marginal. Engineering planning in consultation with affected parties is considered essential to best solve problems arising from the raised water levels, and to create new opportunities for development.

NOTE: *Evaluations in this report were based on preliminary water level information and these assessments were not updated with revised information.*

TERMS OF REFERENCE

The elevation of Footprint Lake will be raised as the result of backwater from increased flows in the Rat-Burntwood River system due to the planned Churchill Diversion Projects by Manitoba Hydro.

The Water Resources Branch has undertaken the preparation of this report on the effects of the raised water level on the shoreline at Nelson House community located on Footprint Lake. For the purposes of this study a value of 35,000 cfs was used as the maximum flow in the Burntwood River under open water conditions. This value consists of 30,000 cfs weekly mean diversion flow and an estimated 5,000 cfs for natural Burntwood River flow and/or allowance for a variation from mean weekly flow.

The elevation of Footprint Lake will also be affected by the future construction of Wuskwatim Dam for which the planned forebay elevation is 800.

On the basis of information available to the Water Resources Branch, the following information established the hydraulic datums for the study.

(a) The new elevation of Footprint Lake at Nelson House would be 802 without Wuskwatim Dam, and 806 with this dam as compared to the present elevation of about 783.5 during August, 1973.

(b) Under ice conditions, the above elevations may be higher by about 3 feet. The elevation of Footprint Lake at Nelson House, may reach 810 taking all possibilities into account.

This report is based on topographic surveys, hydraulic and soils information obtained during the summer of 1973. Reference is made to a concurrently prepared appendix dealing with shoreline erosion at Lac du Bonnet and Pine Falls reservoirs in southern Manitoba involving soils having a similar geological origin.

Bank profile elevations have been referenced to lake level which in turn has been referenced to the Water Surveys of Canada bench mark, (elevation 786.45), at Nelson House.

SCOPE OF STUDY

Figures 1 and 2 locate the study area. Preliminary work included: a visual examination and classification of the existing shoreline, the taking of photographs and the selection of areas for detailed study. Figure 3 summarizes the classification and shows the location of photographs used in the report. Existing topographical data were compiled to provide as complete and up to data as possible plan showing the location of buildings, roads, etc. in relation to the lake and including contour information. This information is presented in Figures 4a and 4b. The figures include acknowledgement of the source information for the contours. Subsequent field work by the Water Resources Branch personnel included cross-section surveys at 14 locations and drilling of test holes at those sections where bedrock outcrop was not evident. Drilling employed a Minute Man power drill, light enough to be manually carried to sites otherwise inaccessible. Limits of time and resources precluded more than one or two test holes at each site investigated, and drilling was stopped when further penetration by auger became impossible. Representative bulk soil samples were obtained and subjected to moisture content and identification tests at the Water Resources Branch, Soil Mechanics Laboratory in Winnipeg. The cross-sections of the banks at the survey locations, the test hole logs, and the summarized test results are shown in Figures 5-1 to 5-5 inclusive.

Analysis of the anticipated effects of the raised water level were made on the basis of the data obtained during the current study and comparison experience elsewhere, including the Lac du Bonnet and Pine Falls reservoirs in southern Manitoba.

GEOTECHNICAL AND SURFICIAL FEATURES

The location of Footprint Lake at Nelson House is mainly established by depressions in the Precambrian bedrock. Wave action has exposed bedrock where bedrock rises steeply from the water. (See Photograph 1, 6, 7, 8 and 14). The bedrock is often covered with substantial thickness of silty-clays and clayey-silts of glacio-lacustrine origin, to form banks that rise 40 to 100 feet or more above the present lake elevation of about 783.

The present stability of some of these banks is marginal. Sliding has taken place at several locations as noted on Figure 3. Two bank profiles at slide locations are shown in cross-sections 11 and 12. Another slide is shown in Photograph 12. It will be noted that the top of sliding just reaches the shoulder of the bank, and the bottom of the slide area is at or near the toe of the bank. This would indicate that sliding was limited by firmer underlying material, possibly a dense glacial till or bedrock. Seepage from higher ground may be a contributing cause to sliding. For the slide shown in cross-section 11, the entire sliding mass of soil is above the present lake level.

Although the 14 test holes, indicated absence of permafrost to the depths drilled, a cautious interpretation is necessary. Without rock-coring, it is not possible to establish with complete reliance that drill refusal is caused by bedrock, boulders, or soil in a frozen-hard condition. The absence of permafrost is a condition which may, however, be expected near the water's edge where the holes were drilled. It has been shown by W.G. Brown(1) and others that lakes act as heat sources preventing the immediately adjacent occurrence of permafrost. The holes were drilled from elevation 810 in order to examine, with a minimum of drilling, soils that would be below the raised water level. In most cases, the 810 contour is close to the present water's edge. Reference to conditions at Thompson, Manitoba, approximately 70 miles to the East, as reported by Baracos and Galay(2), would indicate that permafrost may occur on some banks with heavy tree cover, intact under-brush, and generally northern exposure. The absence of shoreline erosion was observed in sheltered coves and where very gentle fore-shore slopes exist. The fore-shore extends from the low-water line to the normal limit of wave uprush.

Most of the buildings at Nelson House are located on high well-drained ground, as is the airport landing strip.

INUNDATION OF LOW LYING AREAS

Figures 4a and 4b show the areas that will be inundated by raising the elevation of Footprint Lake from its present elevation of 783.5 to 806. The inundated area is only slightly increased by a raise to elevation 810 for which the contour is shown. Inundation of several low lying areas will form an island of a major part of the community as shown in Figure 4a unless a bridge or causeway is built. Several smaller islands will also be formed. The present unimproved roadway from the community to the airstrip would be inundated at three locations, as would the the Highway to Thompson at two locations. Relatively short re-routing is possible on higher ground, or grades may be raised.

Because the banks on which houses are located are relatively high, very few houses would be affected by inundation. Three houses which would be affected by water at elevation 810 are shown on cross-sections 6, 7 and 8. Other facilities that would require re-building at higher elevation include a number of small boat wharfs and a few almost-portable pumphouses. At least one sewer out-fall (there may be more) may require some modification.

Much of the low-lying areas to be inundated is covered by tree growth as is shown in all the Photographs 1 to 16. The trees will require clearing before inundation to provide shoreline access to boats etc., and to permit the development of shorelines comparable to those currently existing.

The raised water level will prove some advantage in reducing pumping heights for water from the lake to the community, and for making the lake more accessible by eliminating much of the present steep slope to water. It will also increase the length of shoreline in the vicinity of the community, and in the new housing development near cross-sections 13 & 14. Shoreline locations are considered attractive for housing.

EROSION AND STABILITY OF BANKS

Figure 5-1 illustrates a high exposed bedrock bank where raised water levels will result in no erosion, and no loss of stability. However, the high bedrock condition represents only about 25 percent of shoreline considered. The more common conditions consist of shorelines where the raised water level of 806, or eventually 810, will be acting on fine grained soils. These soils consist generally of silty clays or clayey silts, which according to the Unified Classification System, are described as CI and CL clays or medium and low plasticity respectively. The classifications based on the laboratory test accompany the test hole logs shown on cross-section 2 to 14 inclusive. An examination of the morphology of the raised shoreline and the consideration of the soil types involved indicate that wave action will be a predominant erosive process at cross-sections 2, 3, 4, 7, 9, 10, 11, 12 & 13. The action of waves will likely be particularly severe at cross-sections 10 and 11, where sliding has already weakened the banks reducing the soils' cohesive strength.

Cross-section 8 will be almost completely inundated by raising the lake level to elevation 806, and completely inundated by raising to elevation 810. It is likely that wave action will quickly remove the soil cover on this cross-section. At cross-sections 5, 6 and 14, only slight wave erosion is anticipated since the new fore-shore profile will be gentle, permitting dissipation of wave energy.

Where erosion takes place, it is expected that it will be similar in form to what has taken place at the Pine Falls and Lac du Bonnet reservoirs. The erosion and the accompanying sliding at Pine Falls and Lac du Bonnet is documented in an information appendix by Baracos and Galay(3). Reference to this appendix will show that soils in both areas are of similar glacio-lacustrine origin. The soils at Nelson House are however, less plastic, containing somewhat more silt. This would tend to reduce the cohesive strength and somewhat increase the susceptibility to erosion. The mean annual temperature of about 26° F at Nelson House, compared to Lac du Bonnet of about 34° F, suggests a shorter ice-free season for wave action at Nelson House, off-setting somewhat the greater susceptibility to erosion. A mean annual temperature of below 32° F, however, introduces the possibility that some inundated soils at Nelson House will contain permafrost which may undergo loss of strength if subject to rapid thawing. However, the test holes showed no evidence of permafrost, although as already noted, its complete absence cannot be taken for granted. The prediction of the rates and extents of erosion of unprotected banks involves many unknown factors. Within the limits of a reasonable budget for preliminary studies, it is not possible to determine with sufficient detail such factors as soil strength, micro-climate at individual banks, local seepage conditions, vegetation or other cover, etc. that would permit a prediction of erosion rates for individual banks. It is even more difficult to predict where eroded banks will subsequently fail by sliding.

Based on comparison of such factors as reservoir sizes, slopes, morphology and soil types, the opinion is expressed that bank recession rates would be comparable to those at corresponding banks at Lac du Bonnet and Pine Falls reservoirs. Bank recession rates ranging from 2 to 5 feet per year over a 20 year period were estimated for these reservoirs. This recession is still continuing. However, what is considered more important than actual rates which could be considerably faster or slower, is the fact that it is possible to effectively protect banks from erosion by the use of rip-rap. For banks where no erosion is to be permitted, rip-rap can be placed before or soon after water levels are raised. Banks requiring such protection could include those adjacent to the airstrip, those with buildings such as shown on Photographs 2 and 3, and at four cemetery locations shown in Figures 4a and 4b. Cemeteries appear to have been located on the banks because of the accessibility of the sites by boat, and also in locations where the soils are easy to excavate. These features unfortunately also make the sites susceptible to erosion and sliding. Photograph 11 shows a cemetery located across the lake from the airstrip, which has had some graves lost by sliding. The Indians highly revere their cemeteries as indicated by the care given to grave maintenance.

It is likely that considerably more rip-rap would be required at Nelson House than the one cubic yard per lineal foot of shoreline used at Lac du Bonnet and Pine Falls, where water levels do not appreciably fluctuate. At Nelson House protection will be required for the lake elevation first raised to 802, then 806, and possibly 810. Reduced diversion flows would introduce water levels lower than elevation 802, requiring further rip-rap to protect between lowest water level and highest wave uprush at a subsequent time.

Generally, the stability of a bank is improved by the action of bouyancy when the bank is inundated. If the water level is subsequently lowered too rapidly to permit soil drainage, a most severe case results. The soil has become saturated, high pore pressures are developed by trapped water and bouyancy has been removed. This can lead to what are called "rapid draw-down" slides of banks previously stable. There is sufficient evidence, such as existing slides and cracks in the soil paralleling the shore, to indicate that banks such as shown in Photograph 2, 5, 9, 10, 11 and 12 would be affected by rapid draw-down slides if the rapid lowering of the lake involved more than a few feet.

Some contrasts can be made to other reservoir experience. R.O. Van Everdingen(4), and J.P. Coakley and P.F. Hamblin(5) report on experiences at Lake Diefenbaker, Saskatchewan, following filling of the reservoir in 1967. Experience has shown wave action, caused by wind, has eroded vertical cliffs which then fail by undercutting or by slides occurring after lowering of water levels. Lake Diefenbaker has undergone rather dramatic erosion attributable to the much greater wind fetch distances, and the presence of glacial tills which have a columner jointing that breaks off on vertical faces. Some slides on Lake Diefenbaker are attributable to rapid draw-down.

Assuming an abrupt cut off diversion flows, and the absence of Wuskwatim dam, the rapid draw-down will be in the order of 18.5 to 21.5 feet, which considering an over-all height of 40 to over 100 feet for the banks, is of appreciable magnitude. Assuming that Wuskwatim dam maintains a forebay elevation of 800, the draw-down would be less than 10 feet. It is deemed necessary that consideration be given to assuring that draw-down rates are sufficiently slow to prevent draw-down sliding, or alternatively, levels are maintained more constant. The latter proposal is to some extent accomplished by having Wuskwatim dam in operation. Alternatively, or in conjunction with Wuskwatim dam, consideration may be given to a control dam on the outlet of Footprint Lake which could give almost constant levels.

Figures 5-1 to 5-5 also include an attempt to forecast what the eventual profiles will be after erosion and sliding have reached an equilibrium condition. Such forecast can only be regarded as speculation, no better than the basis of the erosion hypothesis adopted. Two hypothesis have been used. Both considered erosion as a result of the lake level raised to elevation 806. Ice conditions and wave uprush are considered to establish a fore-shore up to elevation 810. Hypothesis A assumes that in the absence of bedrock, a foreshore similar to Lac du Bonnet will develop. The bank above elevation 810 is assumed to reached an eventual slope of 4 horizontal to 1 vertical consistent with an angle of residual friction of about 20°, estimated from plasticity index values, and with an allowance for some seepage effects. Hypothesis B assumes that erosion will eventually expose bedrock at elevation 810, and the slope above this will be similar to that of the first hypothesis unless it also is controlled by bedrock. Although the lake level may, for some time be at elevation 802, erosion associated with this elevation was not considered.

The length of time this lower elevation would be maintained depends on when Wuskwatim dam is built, and this is currently unknown. Since so many other factors are only estimated, no predictions were considered possible with the lake at elevation 802. The principle merit of these hypothesis is to indicate what banks are not likely to be affected by erosion.

The eventual conditions forecast from the hypothesis may never be reached. Even small quantities of boulders on the newly formed erosion shelf could stop eroding action. Man-made protection could at any time similarly stop the process. Applying the Lac du Bonnet criteria, appreciable erosion can be expected in the first 5 to 12 years with a slower but continuing action thereafter.

In contrast to wave action, current action is considered to have a negligible effect on the erosion at Nelson House.

Such factors as the placing of fill on the upper portions of the banks, seepage from septic fields if these are introduced, and cuts made near the toe of the banks could all be future causes of slides.

CONCLUSIONS AND RECOMMENDATIONS

Inundation of low lying areas will make an island of part of Nelson House and sever some roadways. The roadways are yet relatively unimproved and planning could result in advantageously relocated roads.

A lengthened shoreline will provide additional sites for lakeside property for housing both at Nelson House Indian Reserve and on the adjoining new housing development north of the reserve.

Because most of the existing community is on high ground, approximately 3 or 4 houses may have to be moved.

Erosion of the raised shoreline will occur where the water level will act on banks of clayey silts and silty clays. Much of the bank near currently built-up areas, near the airstrip and near four cemeteries falls in this catagory. The erosion process will not be an instant one, and protective measures can be taken after the water level has been raised. There is some advantage in allowing an erosion shelf to form before placing of rip-rap which can stop the erosion process. The assessment of areas to be protected involves considerable value judgement. Engineering planning in consultation with affected parties is essential in order to minimize problems caused by shoreline inundation, erosion, and draw-down.

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Vic Galay

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1. Brown, W. G., "Simple graphical methods for estimating the location of permafrost under shallow lakes and rivers", Proc. 1st Canadian Con. on Permafrost, April, 1962.

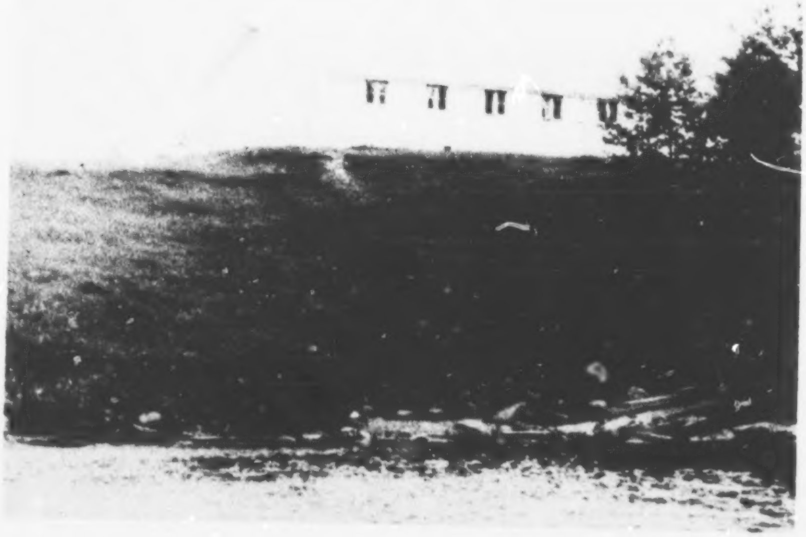
2. Baracos, A. and Galay, V., "Effects of increased flow in the Burntwood River near Thompson, Manitoba", Report for Lake Winnipeg, Churchill and Nelson Rivers Study Board, March, 1973.

3. Baracos, A. and Galay, V., "Shoreline erosion at Lac du Bonnet and Pine Falls reservoirs, Winnipeg River, Manitoba", August 1973. Information appendix included in "Anticipated shoreline effects of raised lake levels at Nelson House, Manitoba", Lake Winnipeg, Churchill and Nelson Rivers Study Board, September, 1973.

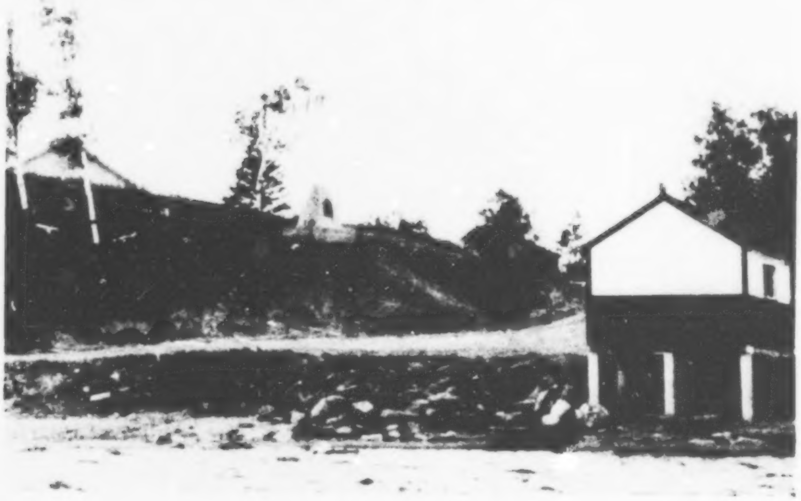
4. Van Everdinger, R. O., "Diefenbaker Lake - Effects of bank erosion on storage capacity", Inland Waters Branch, Canada Department of Energy, Mines and Resources, Technical Bulletin, No. 10.

5. Coakley, J.P. and Hamblin, P.F., "Investigation of bank erosion and nearshore sedimentation in Lake Diefenbaker", Canada Centre for Inland Waters.

PHOTOGRAPH 1 - Bank with bedrock outcrop. No erosion, no sliding anticipated. Tree clearing required to give raised shoreline similar to existing shoreline.



PHOTOGRAPH 2 - Bank where raised water level will lead to wave erosion and possible sliding if not protected with rip-rap.



PHOTOGRAPH 3 - Bank susceptible to wave erosion with raised water level. Light building will have to be raised to higher ground.

PHOTOGRAPH 4 - One of three large cemeteries is located at the top of the bank. A rock ledge at the toe of the bank can support rip-rap protection.

PHOTOGRAPH 5 - The lower portion of this bank is currently unstable. Buildings on top are well above raised water levels.

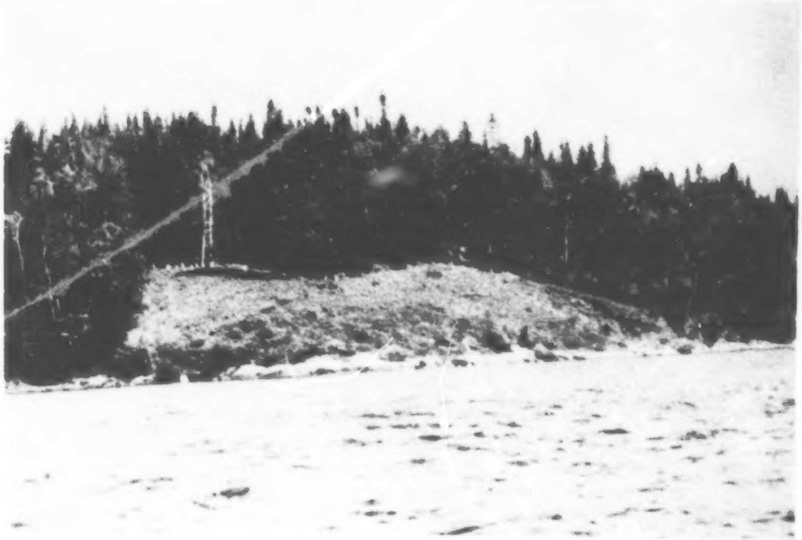
PHOTOGRAPH 6 - Bedrock shoreline that will be little affected by raised water levels but vegetation will require removal to restore previous conditions.

PHOTOGRAPH 7 - Newly constructed homes are well above proposed new water levels.

PHOTOGRAPH 8 - Rip-rap erosion protection may be required after a number of years to protect these homes from erosion and sliding.

PHOTOGRAPH 9 - Cemetery at 'Catholic Point' will eventually require rip-rap protection. A few graves are located outside cemetery areas under trees.

PHOTOGRAPH 10 - One of several slide scars existing above present water level.



PHOTOGRAPH 11 - Existing cemetery where graves have been lost due to sliding above present water level.

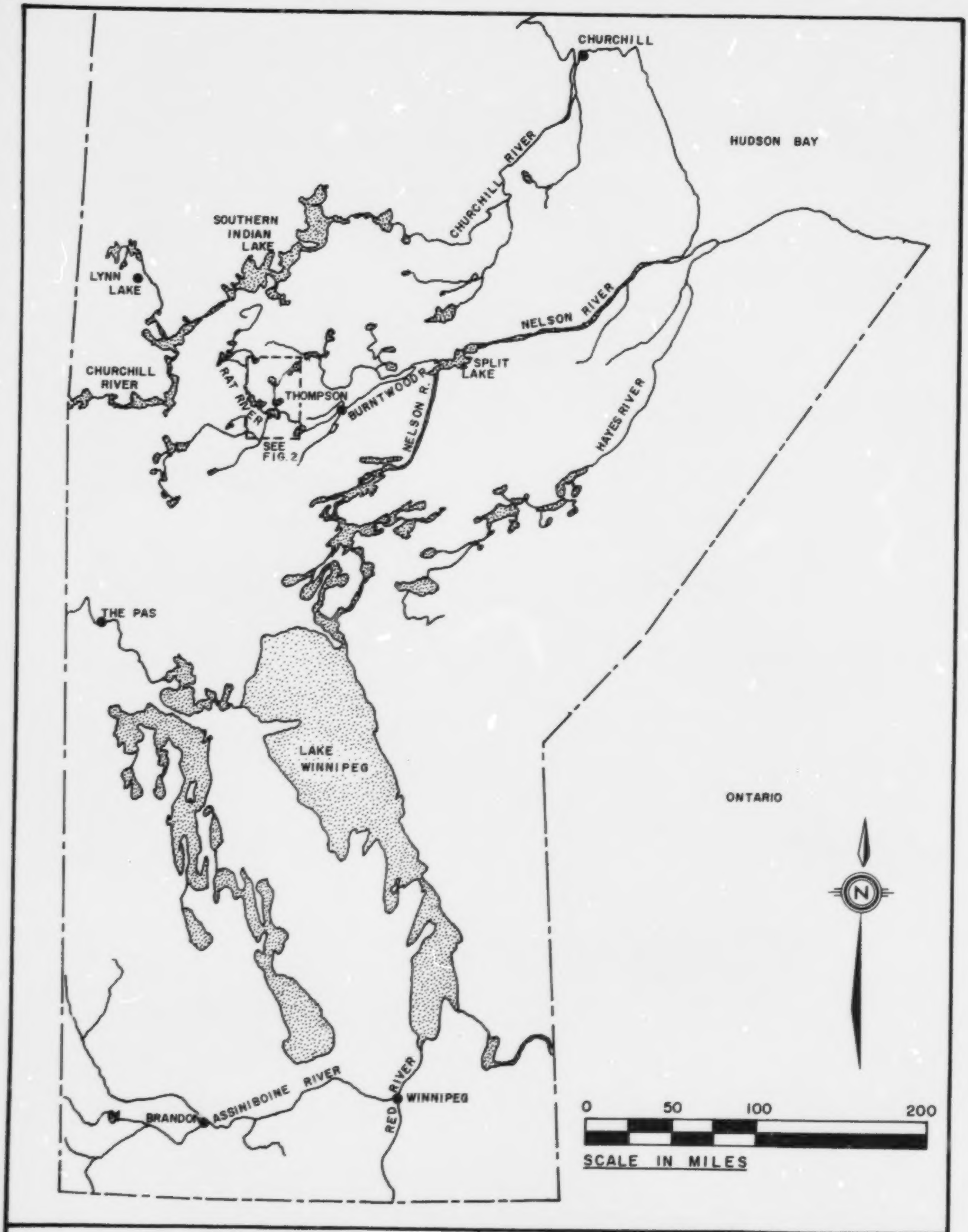
PHOTOGRAPH 12 - Currently unstable bank adjacent to airstrip. Cracks have formed about half way up bank.

PHOTOGRAPH 13 - Sheltered bay adjacent to new housing development north of Nelson House Reserve

PHOTOGRAPH 14 - Bedrock west of sheltered bay shown in Photograph 8.

PHOTOGRAPH 15 - Trees cleared north of airstrip permit view of bank profile.

PHOTOGRAPH 16 - Toe of profile shown in Photograph 15. Exposed bedrock prevents erosion.


CHURCHILL
HUDSON BAY
CHURCHILL RIVER
SOUTHERN INDIAN LAKE
LYNN LAKE
NELSON RIVER
CHURCHILL RIVER
SPLIT LAKE
RAT RIVER
THOMPSON
BURNTWOOD R.
NELSON R.
SEE FIG. 2
HAYES RIVER
THE PAS
LAKE WINNIPEG
ONTARIO
N
0
50
100
200
SCALE IN MILES
ASSINIBOINE RIVER
BRANDON
RED RIVER
WINNIPEG

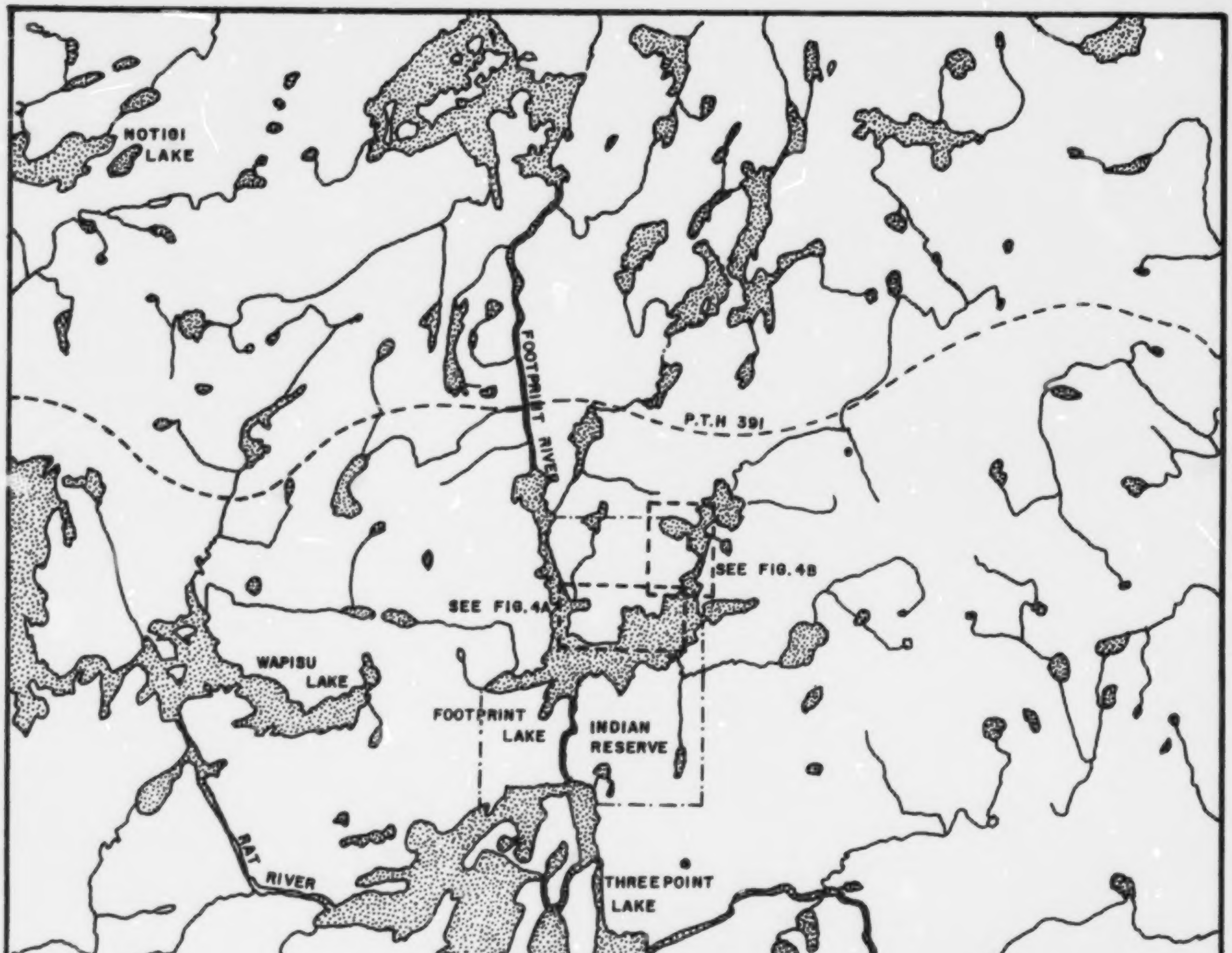
PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA - MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

NELSON HOUSE SETTLEMENT
SHORELINE INVESTIGATION
LOCATION PLAN

FIG. 1

PREPARED
DRAWN
CHECKED
SUBMITTED
DATE
APPROVED
DATE
SCALE
DATE AUG./73
SHEET 1 OF 10
FILE NO. 57-1-1004


NOTIGI LAKE
FOOTPRINT RIVER
P.T.H 391
SEE FIG. 4B
SEE FIG. 4A
WAPISU LAKE
FOOTPRINT LAKE
INDIAN RESERVE
RAT RIVER
THREEPOINT LAKE
BURNTWOOD RIVER
BURNTWOOD RIVER
N
WUSKWATIM LAKE
0 1 2 3 4 5 10
SCALE IN MILES

PROVINCE OF MANITOBA

DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

WATER RESOURCES BRANCH

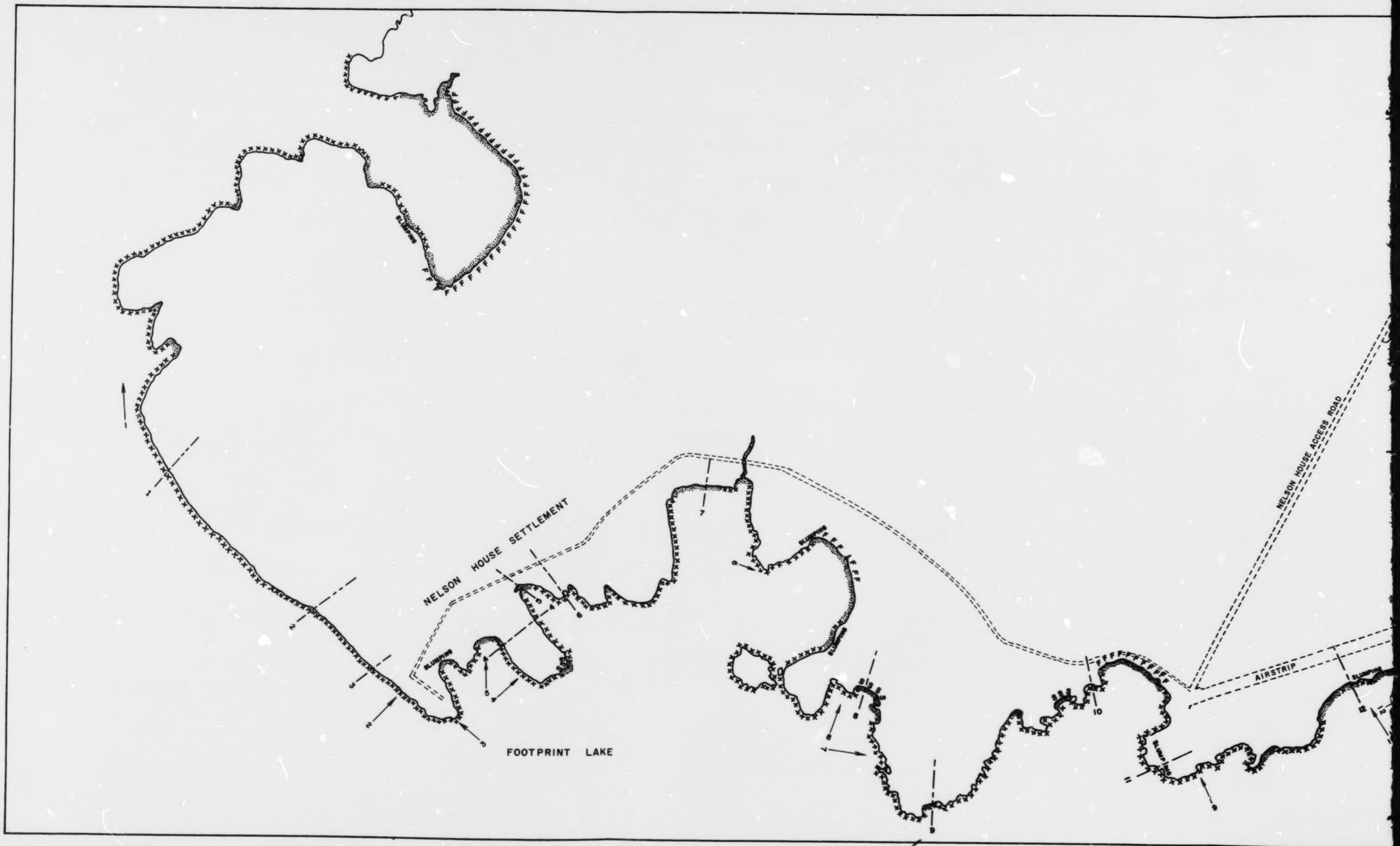
PREPARED	DRAWN	SUBMITTED	APPROVED
	CHECKED	DATE	DATE

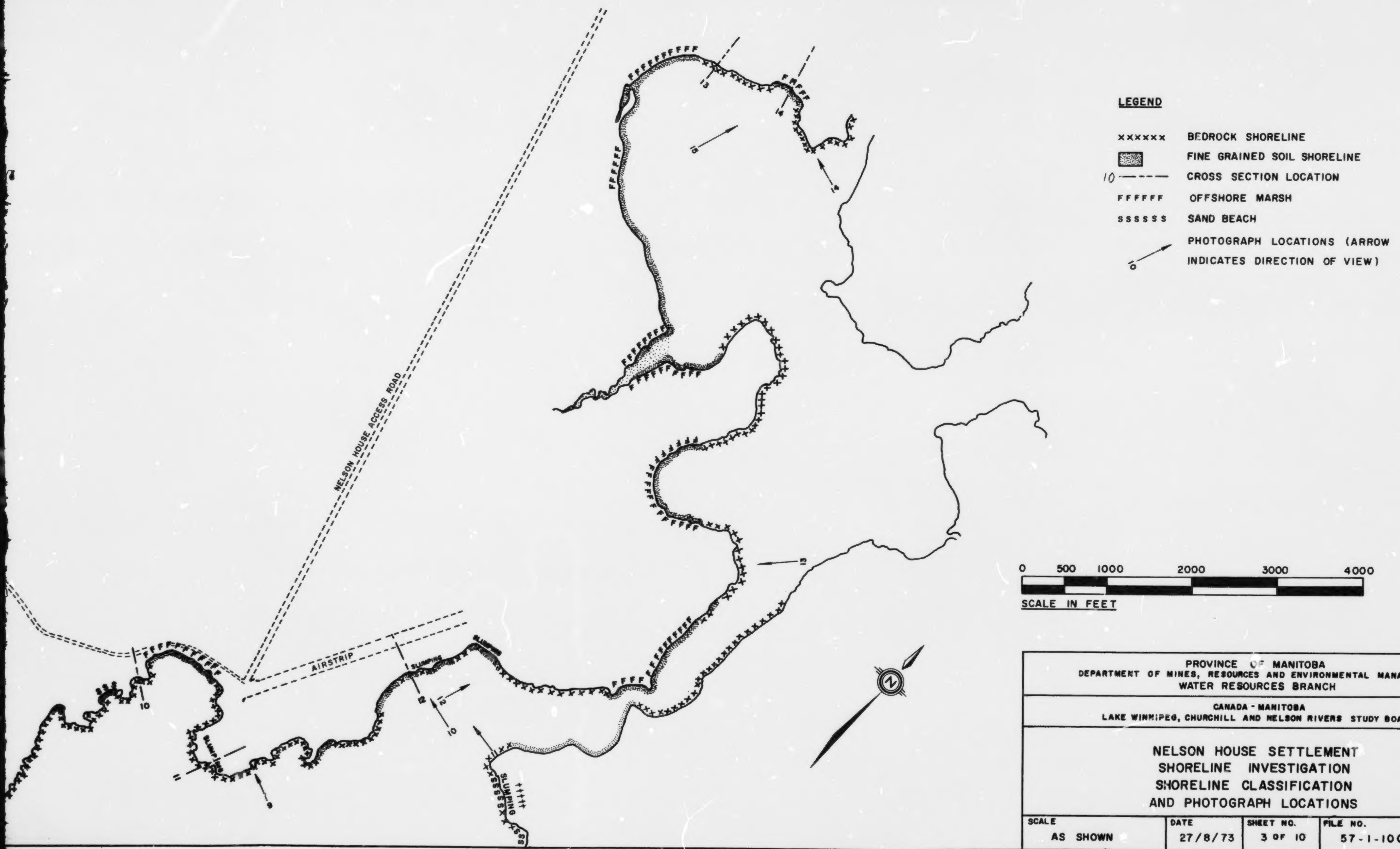
CANADA - MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

NELSON HOUSE SETTLEMENT
SHORELINE INVESTIGATION
KEY PLAN

FIG. 2

SCALE	DATE AUG/73	SHEET 2 OF 10	FILE NO. 57-1-1004


NELSON HOUSE SETTLEMENT
FOOTPRINT LAKE
NELSON HOUSE ACCESS ROAD
AIRSTRIP
SLUMPING
1
2
2
3
3
4
5
6
7
8
9
10
11


LEGEND
×××××× BEDROCK SHORELINE
▨ FINE GRAINED SOIL SHORELINE
10 - - - - CROSS SECTION LOCATION
FFFFFF OFFSHORE MARSH
SSSSSS SAND BEACH
PHOTOGRAPH LOCATIONS (ARROW INDICATES DIRECTION OF VIEW)
0
500
1000
2000
3000
4000
SCALE IN FEET
NELSON HOUSE ACCESS ROAD
AIRSTRIP
SLUMPING
N
9
10
11
12
13
14
15

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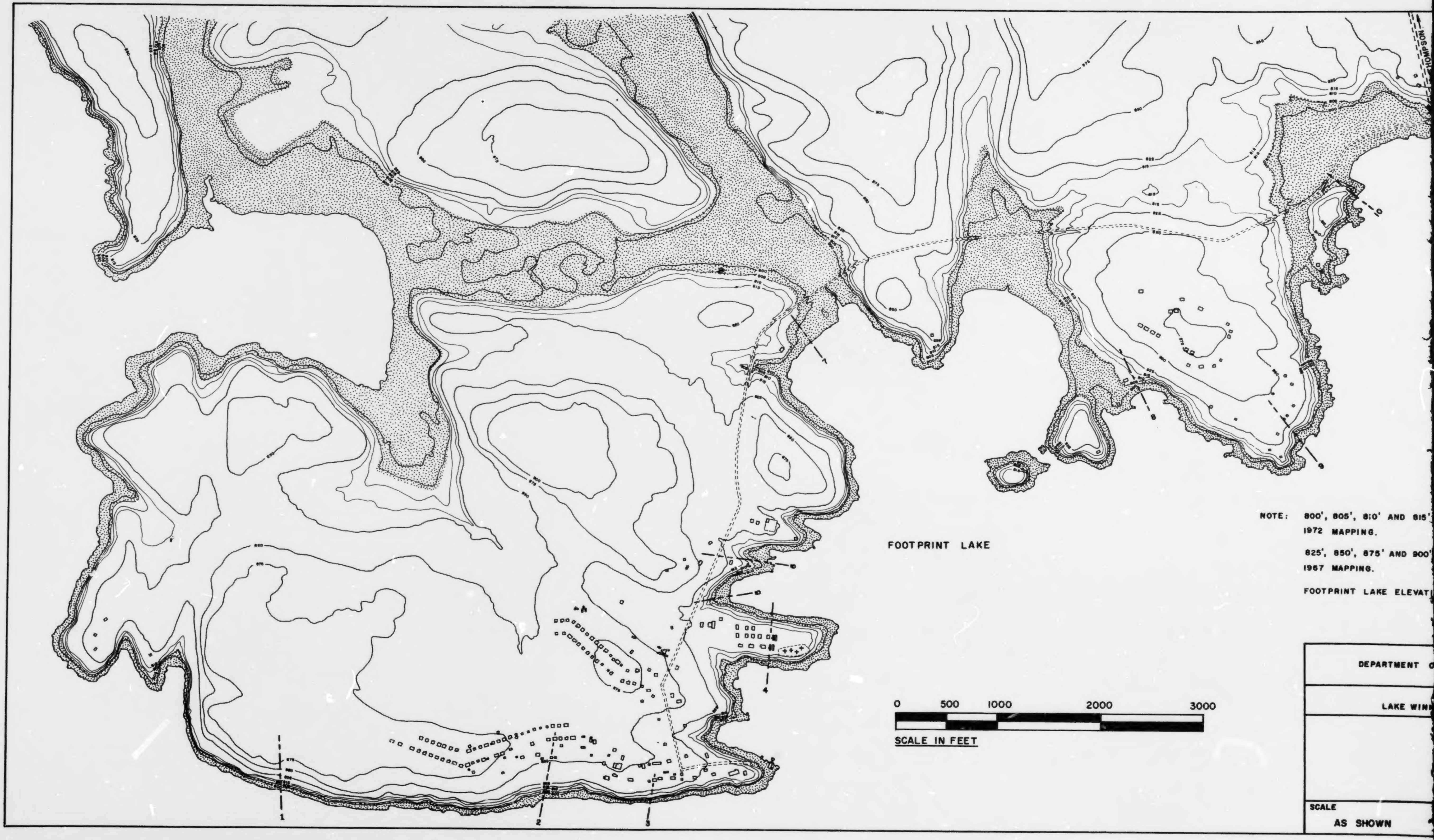
NELSON HOUSE SETTLEMENT
SHORELINE INVESTIGATION
SHORELINE CLASSIFICATION
AND PHOTOGRAPH LOCATIONS

FIG. 3

SCALE	DATE	SHEET NO.	FILE NO.
AS SHOWN	27/8/73	3 OF 10	57-1-1004


HOMPSON
FOOTPRINT LAKE
0
500
1000
2000
3000
SCALE IN FEET
1
2
3
4
8
9
10

NOTE: 800', 805', 810' AND 815'
1972 MAPPING.

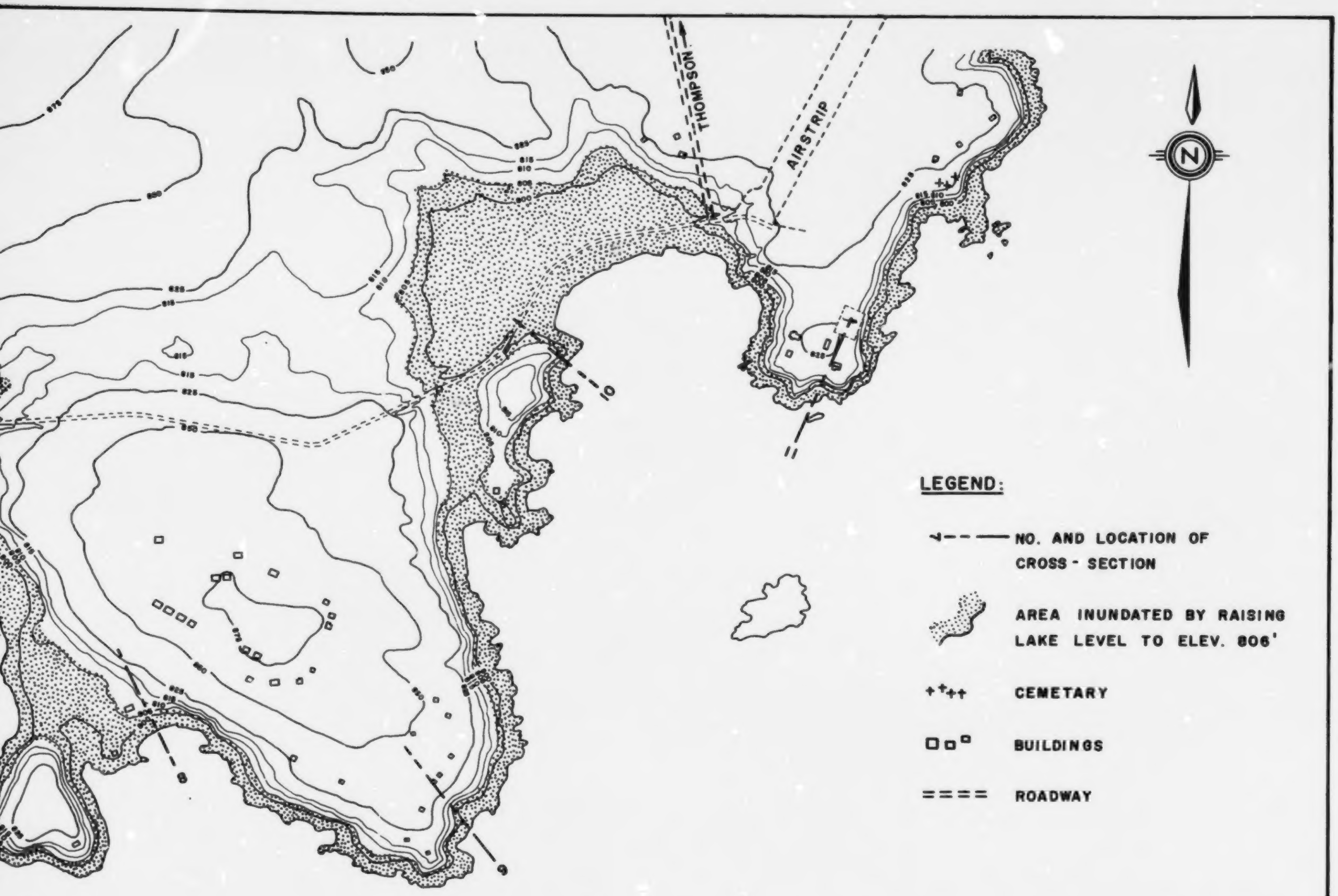
825', 850', 875' AND 900'
1967 MAPPING.

FOOTPRINT LAKE ELEVAT

DEPARTMENT O

LAKE WIN

SCALE
AS SHOWN


THOMPSON
AIRSTRIP
N
950
875
900
825
815
810
806
800
850
10
8
9
LEGEND:
NO. AND LOCATION OF CROSS - SECTION
AREA INUNDATED BY RAISING LAKE LEVEL TO ELEV. 806'
CEMETARY
BUILDINGS
ROADWAY

NOTE: 800', 805', 810' AND 815' CONTOURS BASED ON LOCKWOOD SURVEY 1972 MAPPING.

825', 850', 875' AND 900' CONTOURS BASED ON WESTERN PHOTOGRAMMETRY 1967 MAPPING.

FOOTPRINT LAKE ELEVATION JULY 1973 783.5'

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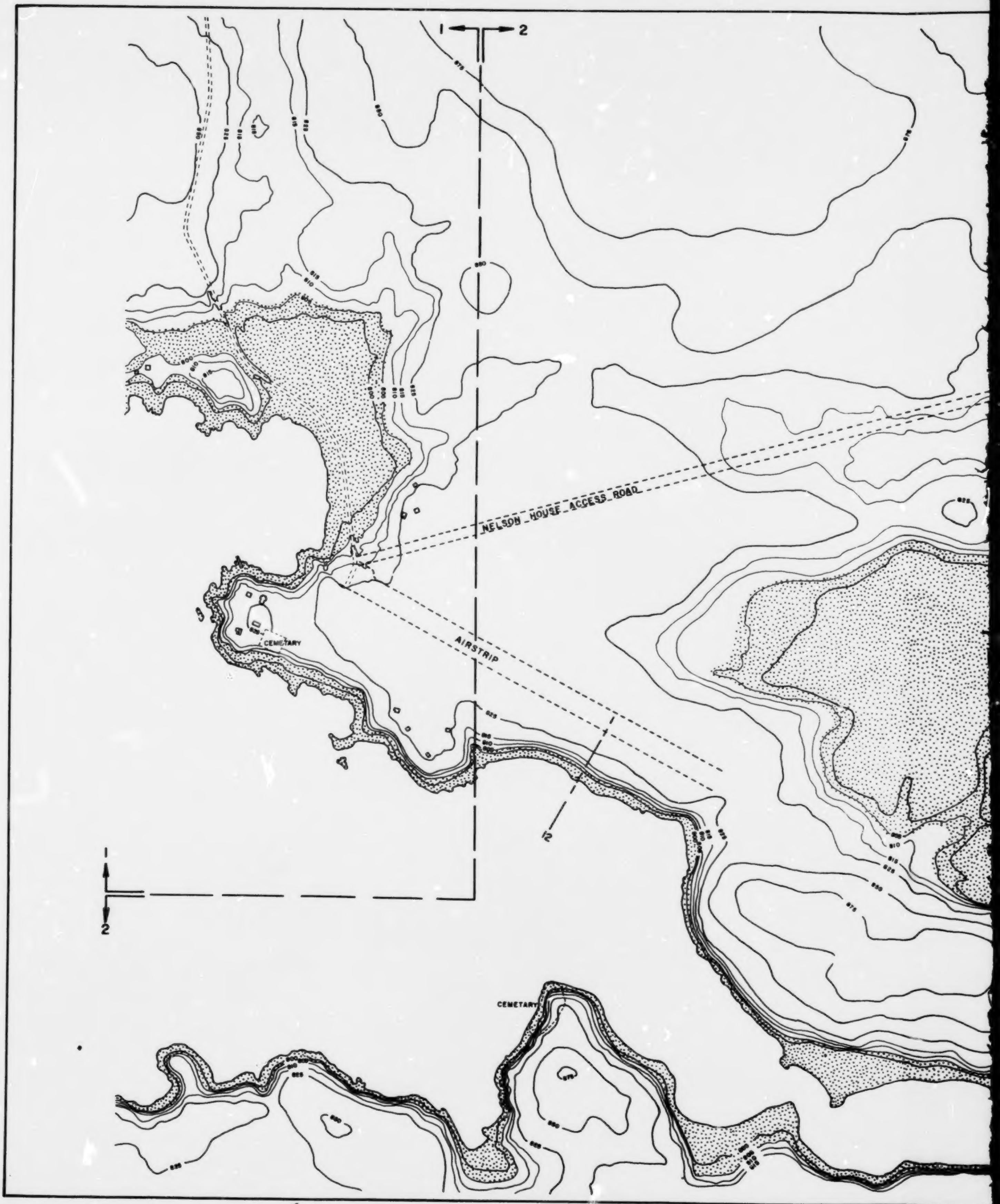
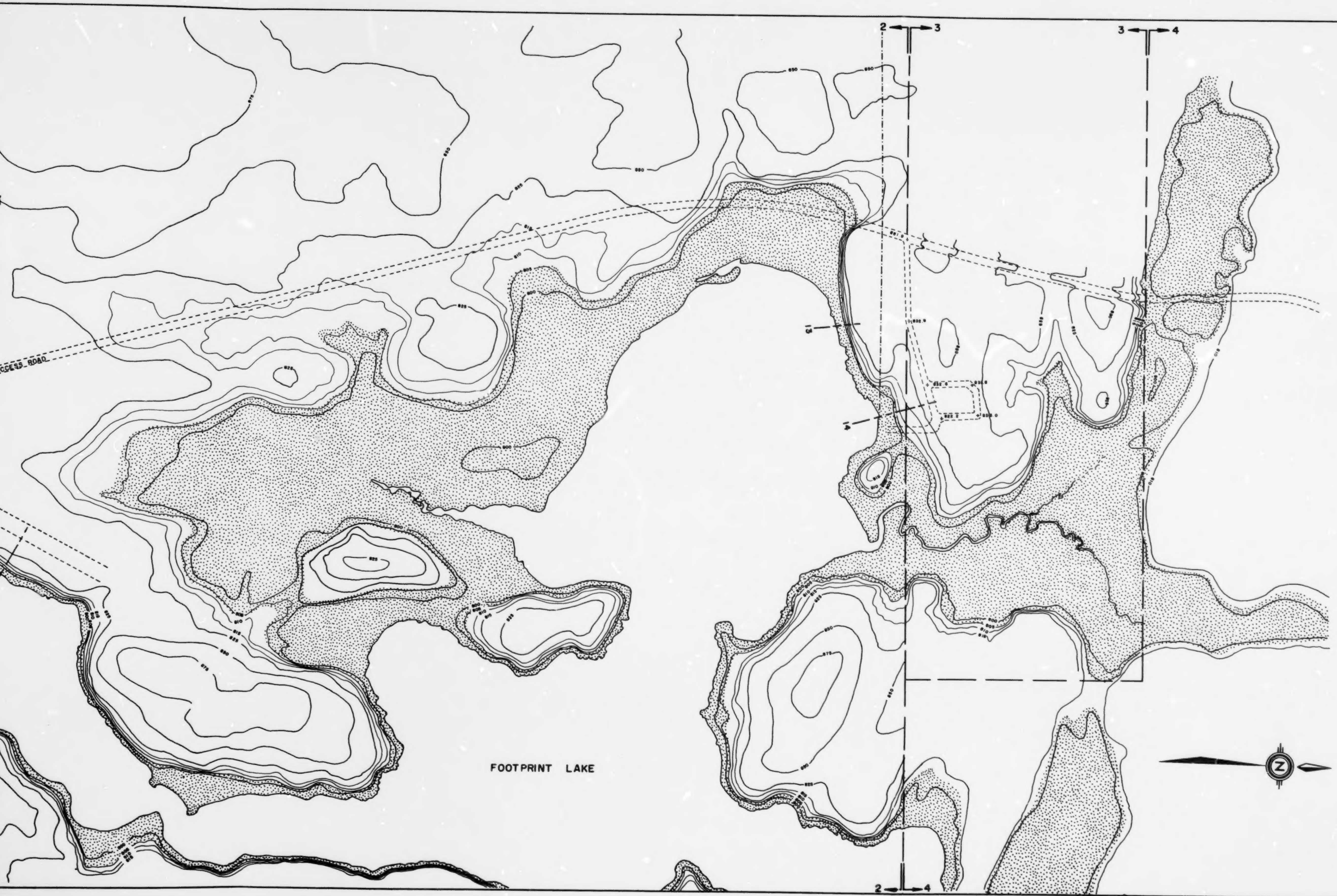
NELSON HOUSE SETTLEMENT
SHORELINE INVESTIGATION
CONTOUR PLAN (SOUTH HALF)

FIG. 4 - A

SCALE	DATE	SHEET NO.	FILE NO.
AS SHOWN	27/8/73	4 OF 10	57 - 1 -1004


1
2
NELSON HOUSE ACCESS ROAD
AIRSTRIP
CEMETARY
CEMETARY
12
1
2
875
850
825
810
800



LEGEND:

- --- NO. AND LOCATION OF CROSS SECTION
- ▨ AREA INUNDATED BY R LAKE LEVEL TO ELEV.
- ++++ CEMETARY
- □□□ BUILDINGS
- ==== ROADWAY

NOTE: CONTOURS IN SECTION 1-1 BASED FIGURE 4A

CONTOURS IN SECTION 2-2 BASED 1967 MAPPING

CONTOURS IN SECTION 3-3 BASE 1972 MAPPING

CONTOURS IN SECTION 4-4 BASE MAPPING PROJECT 1972

FOOTPRINT LAKE ELEVATION JUL

0 500 1000

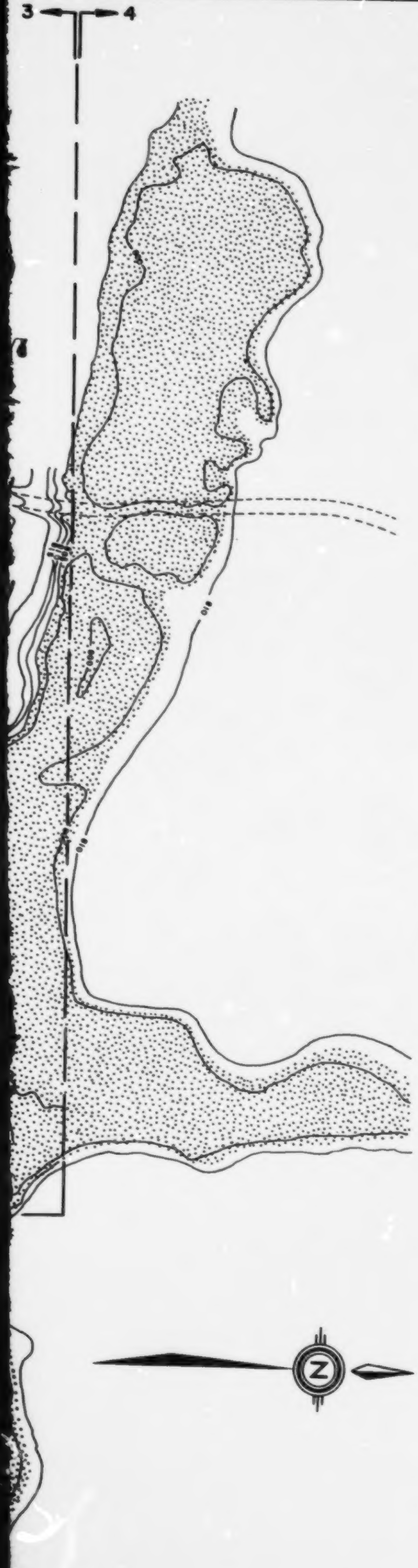
SCALE IN FEET

PROVINCE O
DEPARTMENT OF MINES, RESOURCES
WATER RESOU

CANADA -
LAKE WINNIPEG, CHURCHILL AN

NELSON HOUSE
SHORELINE IN
CONTOUR PLAN

SCALE	DATE	SH
AS SHOWN	27/8/73	



LEGEND:

3 - - — NO. AND LOCATION OF CROSS SECTION

▨ AREA INUNDATED BY RAISING LAKE LEVEL TO ELEV. 806'

✝✝✝✝ CEMETARY

□▫▫ BUILDINGS

==== ROADWAY

NOTE:

CONTOURS IN SECTION 1-1 BASED ON FIGURE 4A

CONTOURS IN SECTION 2-2 BASED ON WESTERN PHOTOGRAMMETRY 1967 MAPPING

CONTOURS IN SECTION 3-3 BASED ON LOCKWOOD SURVEY 1972 MAPPING

CONTOURS IN SECTION 4-4 BASED ON BURNTWOOD RIVER MAPPING PROJECT 1972

FOOTPRINT LAKE ELEVATION JULY 1973 783.5'

0 500 1000 2000 3000

SCALE IN FEET

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WATER RESOURCES BRANCH

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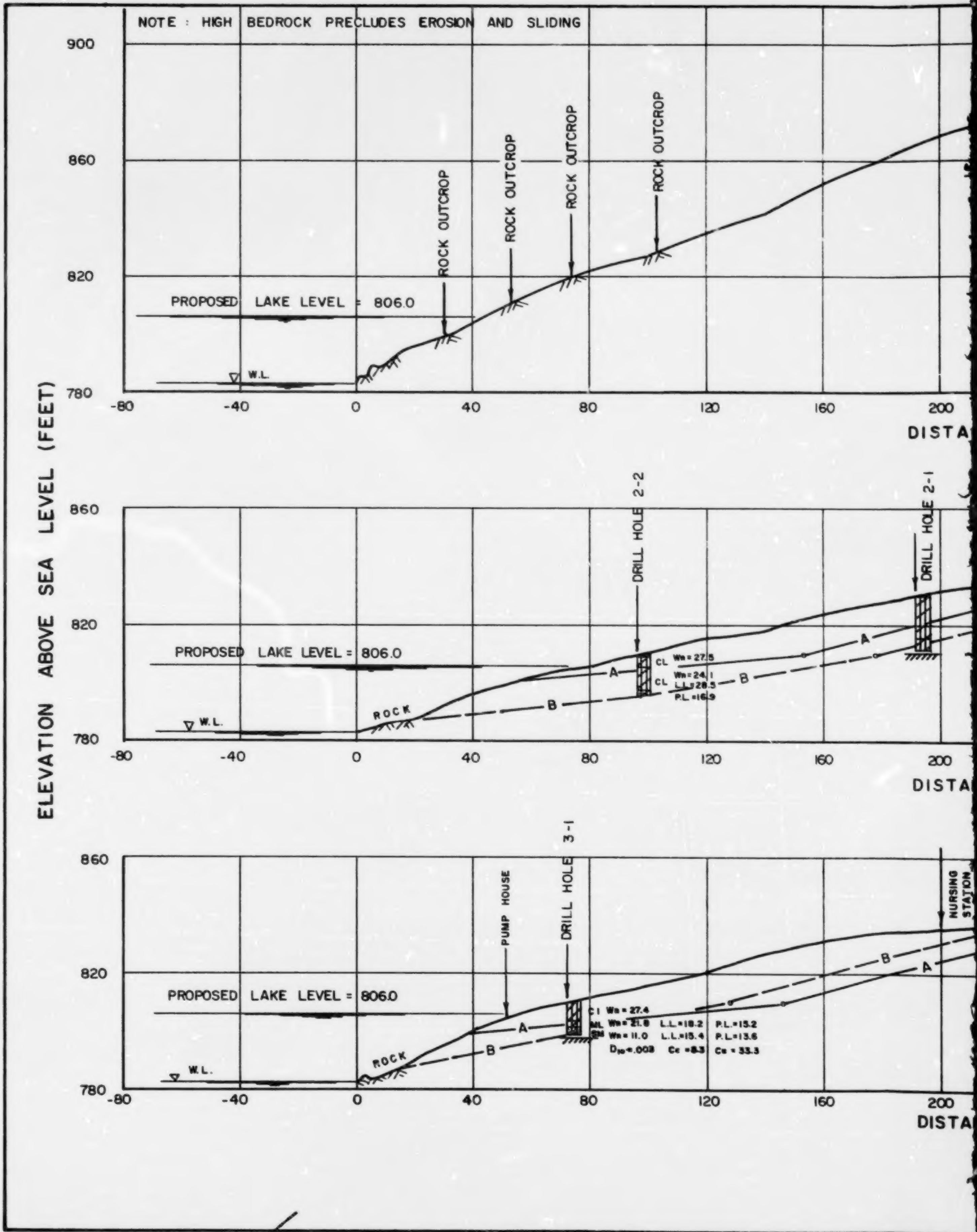
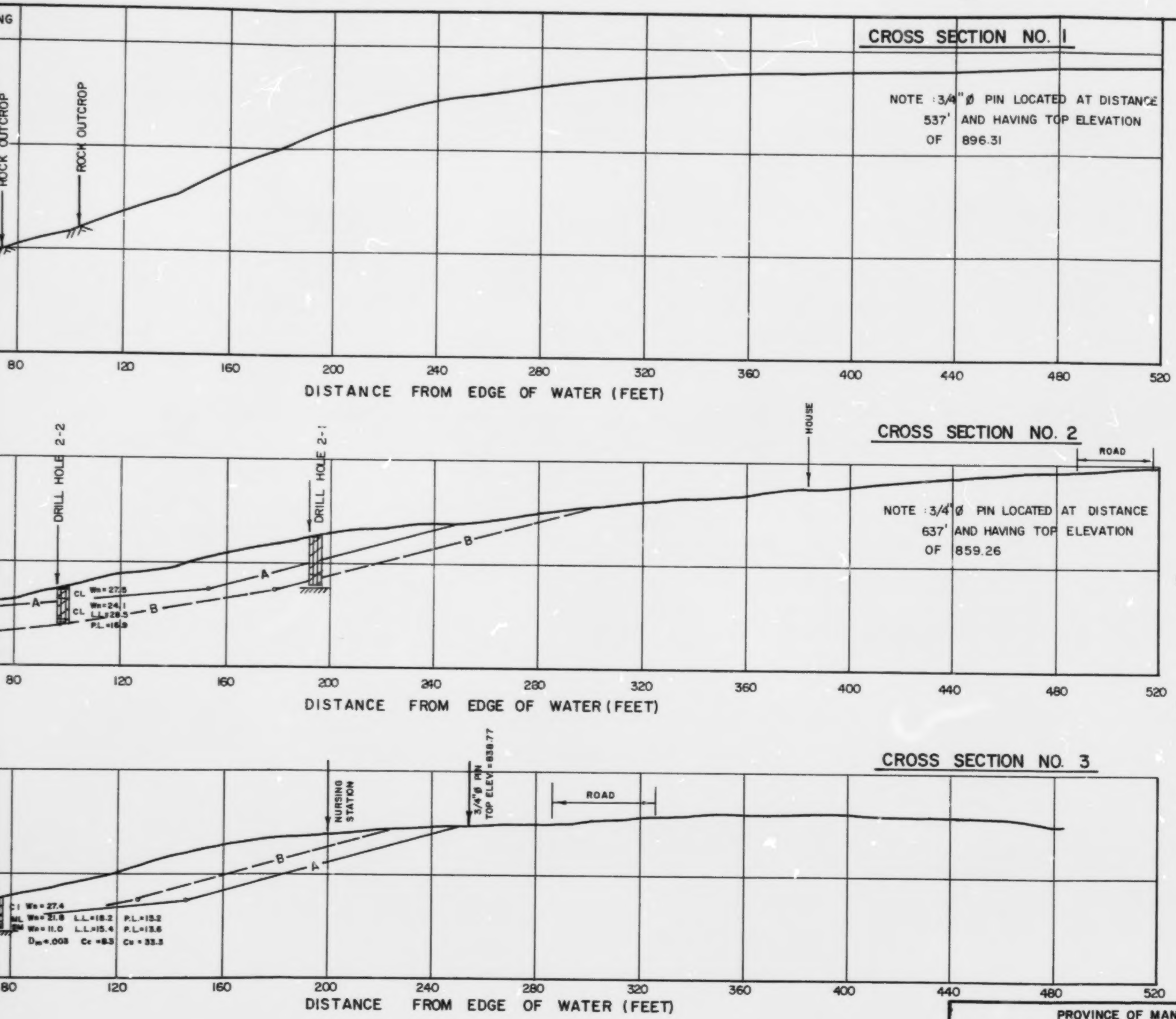
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

NELSON HOUSE SETTLEMENT
SHORELINE INVESTIGATION
CONTOUR PLAN (NORTH HALF)

FIG. 4-B

SCALE	DATE	SHEET NO.	FILE NO.
AS SHOWN	27/8/73	5 OF 10	57-1-1004

NOTE : HIGH BEDROCK PRECLUDES EROSION AND SLIDING
ELEVATION ABOVE SEA LEVEL (FEET)
900
860
820
780
ROCK OUTCROP
ROCK OUTCROP
ROCK OUTCROP
ROCK OUTCROP
PROPOSED LAKE LEVEL = 806.0
W.L.
-80
-40
0
40
80
120
160
200
DISTA
860
820
780
DRILL HOLE 2-2
DRILL HOLE 2-1
PROPOSED LAKE LEVEL = 806.0
CL Wn = 27.5
CL Wn = 24.1
L.L.=28.5
P.L.=16.9
A
B
ROCK
W.L.
-80
-40
0
40
80
120
160
200
DISTA
860
820
780
PUMP HOUSE
DRILL HOLE 3-1
NURSING STATION
PROPOSED LAKE LEVEL = 806.0
CI Wn = 27.4
ML Wn = 21.8 L.L.=18.2 P.L.=13.2
SM Wn = 11.0 L.L.=15.4 P.L.=13.6
D10=.003 Cc =8.3 Cu = 33.3
A
B
ROCK
W.L.
-80
-40
0
40
80
120
160
200
DISTA


CROSS SECTION NO. 1
NOTE : 3/4"Ø PIN LOCATED AT DISTANCE 537' AND HAVING TOP ELEVATION OF 896.31
ROCK OUTCROP
ROCK OUTCROP
80
120
160
200
240
280
320
360
400
440
480
520
DISTANCE FROM EDGE OF WATER (FEET)
CROSS SECTION NO. 2
DRILL HOLE 2-2
DRILL HOLE 2-1
HOUSE
ROAD
NOTE : 3/4"Ø PIN LOCATED AT DISTANCE 637' AND HAVING TOP ELEVATION OF 859.26
A
B
CL Wn=27.5
CL Wn=24.1
L.L.=28.5
P.L.=16.9
80
120
160
200
240
280
320
360
400
440
480
520
DISTANCE FROM EDGE OF WATER (FEET)
CROSS SECTION NO. 3
NURSING STATION
3/4"Ø PIN TOP ELEV.=838.77
ROAD
A
B
CI Wn=27.4
ML Wn=21.8 L.L.=18.2 P.L.=15.2
SM Wn=11.0 L.L.=15.4 P.L.=13.6
D10=.003 Cc=8.3 Cu=33.3
80
120
160
200
240
280
320
360
400
440
480
520
DISTANCE FROM EDGE OF WATER (FEET)

CROSS SECTION LEGEND

PROFILE AS SURVEYED JULY 1973

—A—o—A— EVENTUAL PROFILE AFTER EROSION AND SLIDING ASSUMING HYPOTHESIS 'A'

—B—o—B— EVENTUAL PROFILE AFTER EROSION AND SLIDING ASSUMING HYPOTHESIS 'B'

SOIL LEGEND

▤ ORGANIC

▥ SILT

▨ CLAY

░ SAND

POSSIBLE BEDROCK

BEDROCK OUTCROP

NOTE : ALL ELEVATIONS BASED ON WATER SURVEY OF CANADA BENCH MARK LOCATED ADJACENT TO MANITOBA GOVERNMENT DOCK AND HAVING ELEVATION OF 786.45 G.S.C.

NOTE : FOOT PRINT LAKE ELEVATION AT TIME OF SURVEY IS 783.5

FIG. 5-1

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

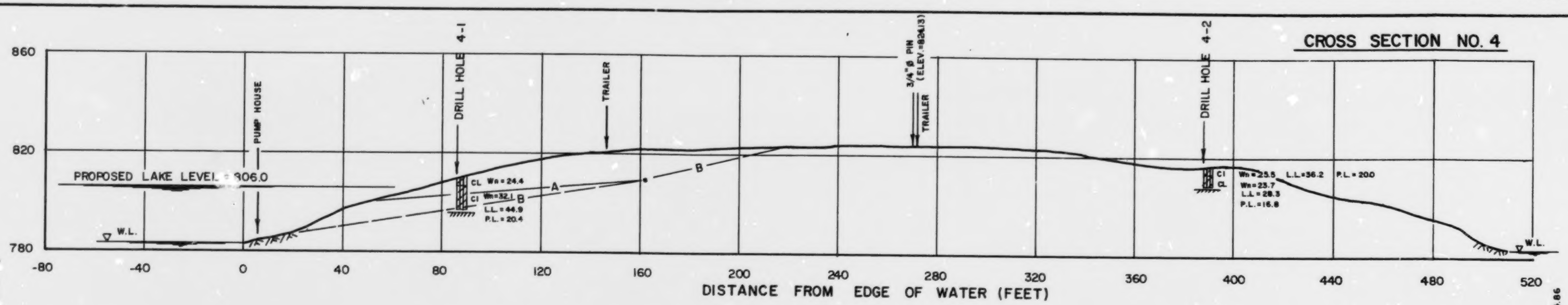
PREPARED F.P.
DRAWN D.K.
CHECKED
SUBMITTED
DATE
APPROVED
DATE

CANADA - MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

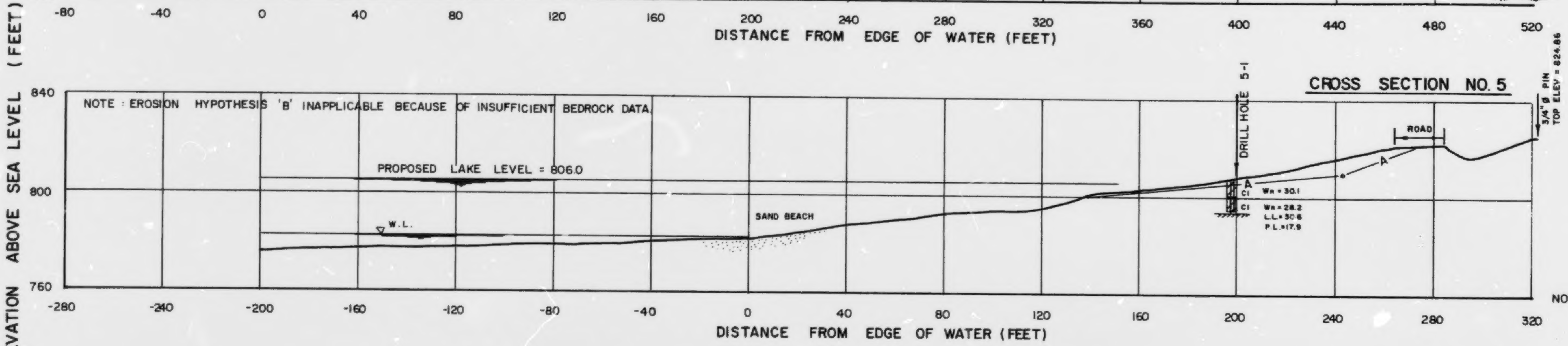
NELSON HOUSE SETTLEMENT
SHORELINE INVESTIGATION
CROSS SECTION NO. 1, 2 & 3

SCALE AS SHOWN
DATE JAN 1975
SHEET 6 of 10
FILE No. 57-1-1004

CROSS SECTION NO. 4

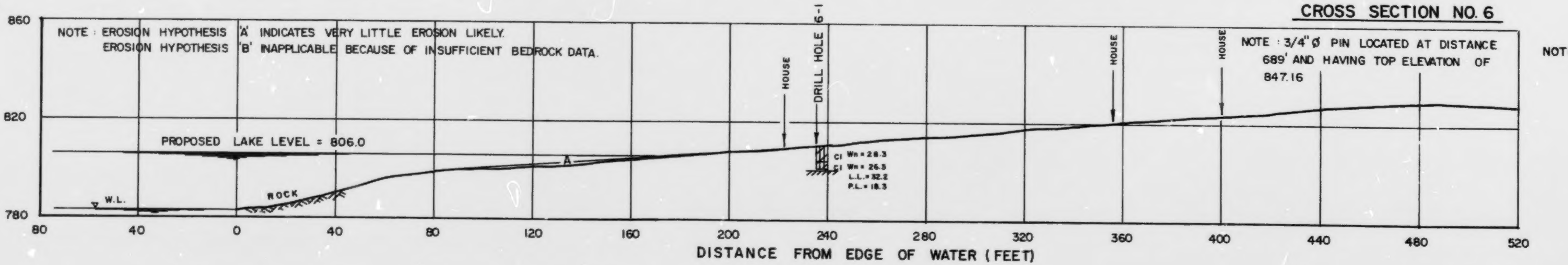

860
820
780
DRILL HOLE 4-1
TRAILER
3/4" Ø PIN (ELEV.=824.13)
TRAILER
DRILL HOLE 4-2
PUMP HOUSE
PROPOSED LAKE LEVEL = 806.0
W.L.
A
B
CL Wn = 24.4
CI Wn = 32.1
L.L. = 44.9
P.L. = 20.4
CI Wn = 25.5 L.L. = 36.2 P.L. = 20.0
CL Wn = 23.7
L.L. = 28.3
P.L. = 16.8
W.L.
-80
-40
0
40
80
120
160
200
240
280
320
360
400
440
480
520
DISTANCE FROM EDGE OF WATER (FEET)

CROSS SECTION NO. 5


ELEVATION ABOVE SEA LEVEL (FEET)
840
800
760
PROPOSED LAKE LEVEL = 806.0
W.L.
SAND BEACH
DRILL HOLE 5-1
A
CI Wn = 30.1
CI Wn = 28.2
L.L. = 30.6
P.L. = 17.9
ROAD
3/4" Ø PIN TOP ELEV = 824.86
-280
-240
-200
-160
-120
-80
-40
0
40
80
120
160
200
240
280
320
DISTANCE FROM EDGE OF WATER (FEET)

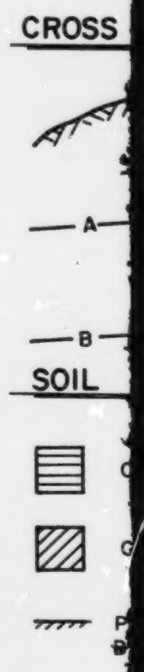
NOTE : EROSION HYPOTHESIS 'B' INAPPLICABLE BECAUSE OF INSUFFICIENT BEDROCK DATA.

CROSS SECTION NO. 6


860
820
780
PROPOSED LAKE LEVEL = 806.0
W.L.
ROCK
A
HOUSE
DRILL HOLE 6-1
HOUSE
HOUSE
CI Wn = 28.3
CI Wn = 26.3
L.L. = 32.2
P.L. = 18.3
80
40
0
40
80
120
160
200
240
280
320
360
400
440
480
520
DISTANCE FROM EDGE OF WATER (FEET)

NOTE : EROSION HYPOTHESIS 'A' INDICATES VERY LITTLE EROSION LIKELY.
EROSION HYPOTHESIS 'B' INAPPLICABLE BECAUSE OF INSUFFICIENT BEDROCK DATA.

NOTE : 3/4" Ø PIN LOCATED AT DISTANCE 689' AND HAVING TOP ELEVATION OF 847.16


CROSS
A
B
SOIL

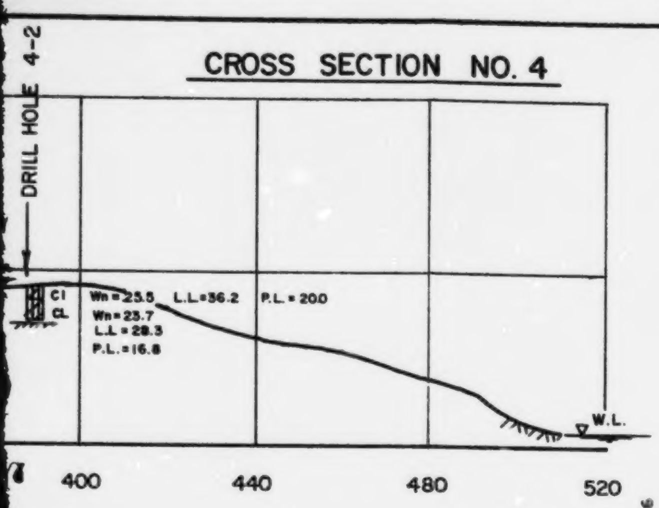
NOTE : ALL
BENC
DOC

NOTE : FOOT

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MAN
WATER RESOURCES BRANCH

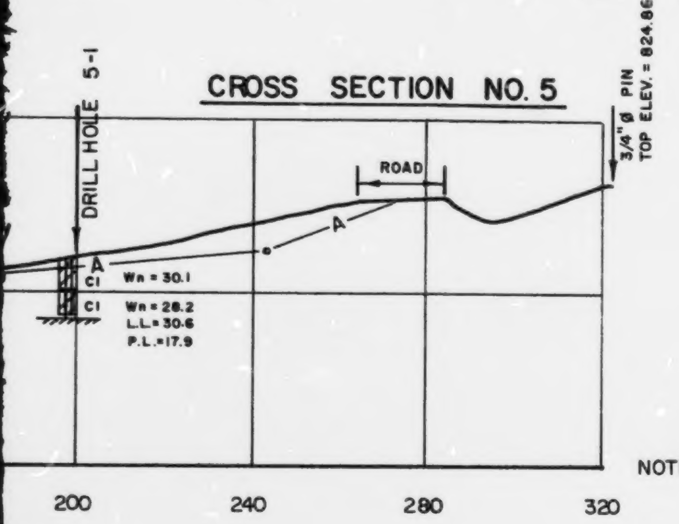
PREPARED	DRAWN D.K.	SUBMITTED	APP
F. P.	CHECKED	DATE	DATE

CROSS SECTION NO. 4



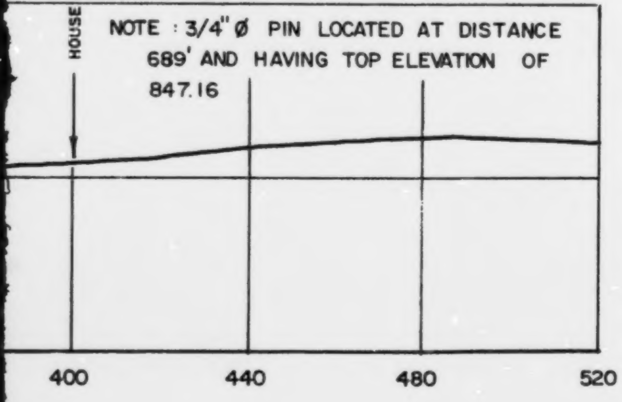
DRILL HOLE 4-2
CI
CL
Wn = 23.5
L.L = 36.2
P.L = 200
Wn = 23.7
L.L = 28.3
P.L = 16.8
W.L.
400
440
480
520

CROSS SECTION NO. 5



DRILL HOLE 5-1
3/4" Ø PIN
TOP ELEV. = 824.86
ROAD
A
A
CI
Wn = 30.1
CI
Wn = 28.2
L.L = 30.6
P.L = 17.9
200
240
280
320

CROSS SECTION NO. 6



HOUSE
NOTE : 3/4" Ø PIN LOCATED AT DISTANCE 689' AND HAVING TOP ELEVATION OF 847.16
400
440
480
520

CROSS SECTION LEGEND

PROFILE AS SURVEYED JULY 1973

— A —o— A — EVENTUAL PROFILE AFTER EROSION AND SLIDING ASSUMING HYPOTHESIS 'A'

— B —o— B — EVENTUAL PROFILE AFTER EROSION AND SLIDING ASSUMING HYPOTHESIS 'B'

SOIL LEGEND

☰	ORGANIC	▥	SILT
▨	CLAY	⬚	SAND
⁄⁄⁄⁄⁄	POSSIBLE BEDROCK	⁄⁄⁄≡⁄⁄⁄	BEDROCK OUTCROP

NOTE : ALL ELEVATIONS BASED ON WATER SURVEY OF CANADA BENCH MARK LOCATED ADJACENT TO MANITOBA GOVERNMENT DOCK AND HAVING ELEVATION OF 786.45 G.S.C.

NOTE : FOOT PRINT LAKE ELEVATION AT TIME OF SURVEY IS 783.5

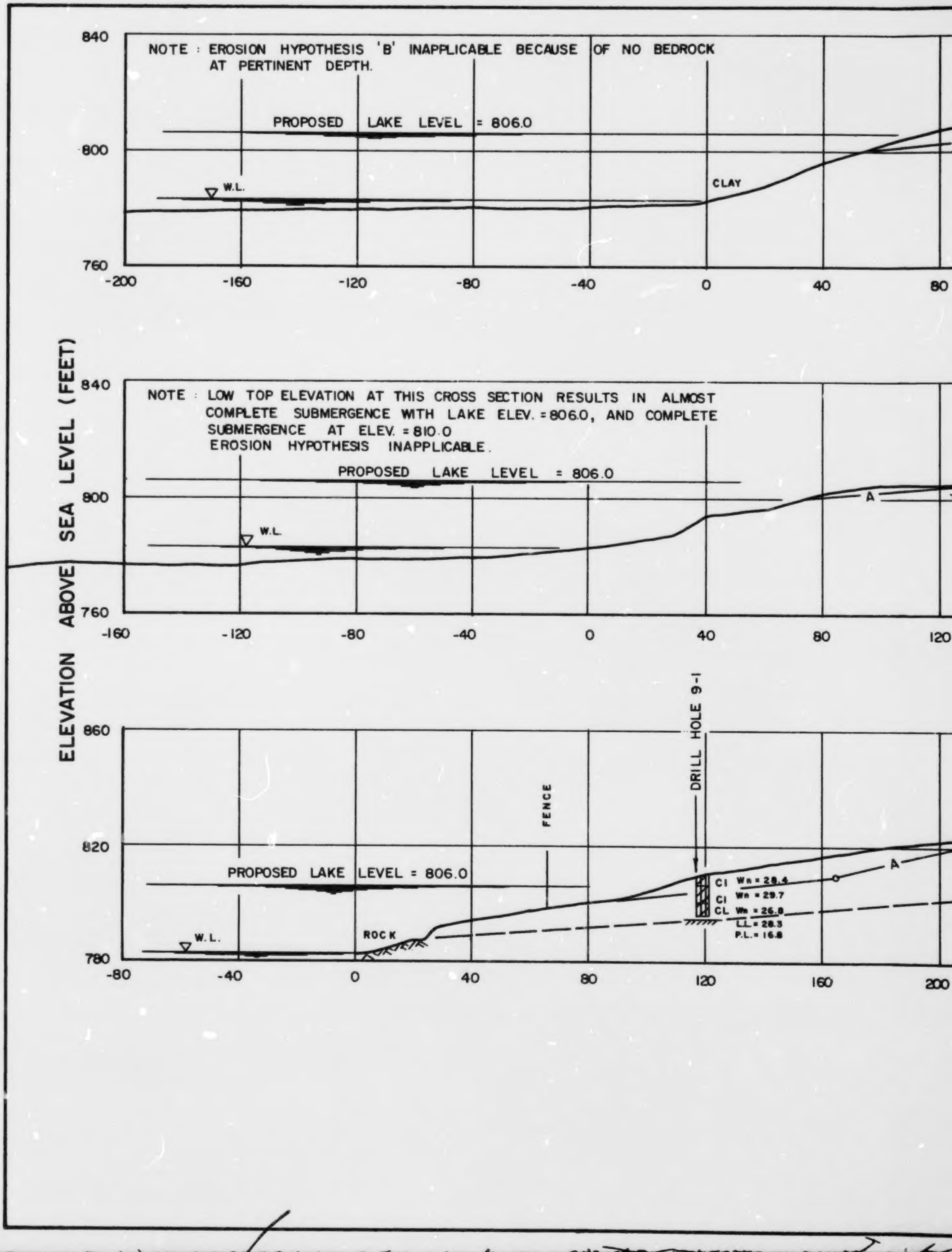
FIG. 5-2

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA-MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD
NELSON HOUSE SETTLEMENT
SHORELINE INVESTIGATION
CROSS SECTION NO. 4, 5 & 6

PREPARED	DRAWN	SUBMITTED	APPROVED
F. P.	D. K.		
	CHECKED	DATE	DATE

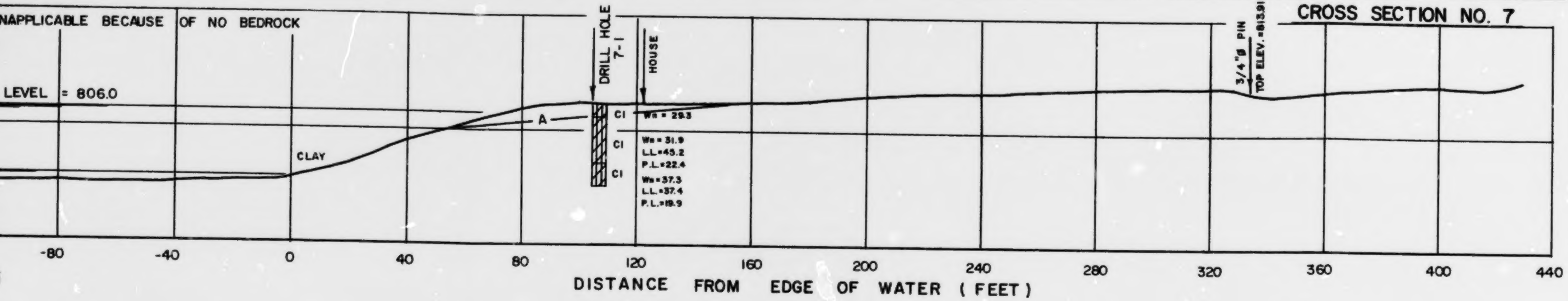
SCALE	DATE	SHEET	FILE NO.
AS SHOWN	JAN 1975	7 OF 10	57-1-1004

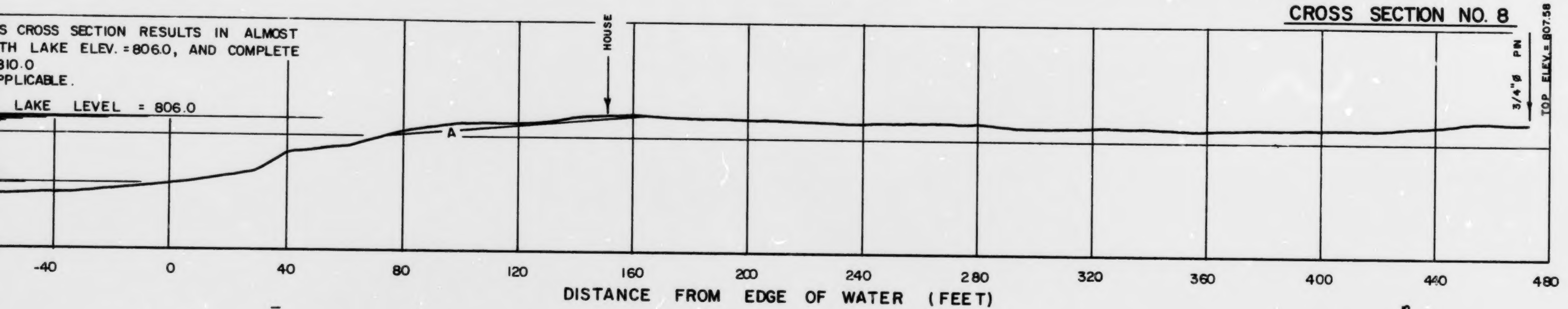


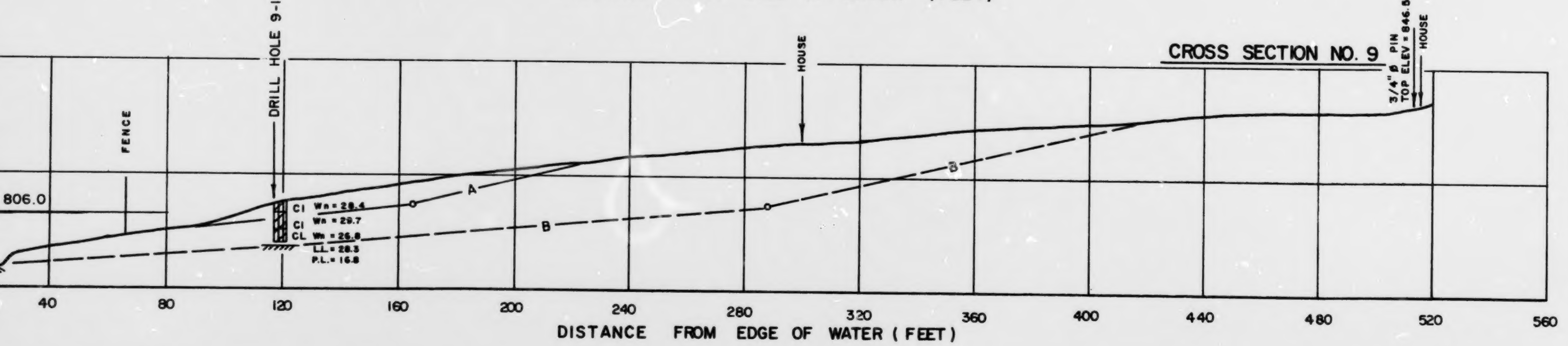
NOTE : EROSION HYPOTHESIS 'B' INAPPLICABLE BECAUSE OF NO BEDROCK AT PERTINENT DEPTH.

NOTE : LOW TOP ELEVATION AT THIS CROSS SECTION RESULTS IN ALMOST COMPLETE SUBMERGENCE WITH LAKE ELEV. = 806.0, AND COMPLETE SUBMERGENCE AT ELEV. = 810.0
EROSION HYPOTHESIS INAPPLICABLE.

ELEVATION ABOVE SEA LEVEL (FEET)
840
800
760
-200
-160
-120
-80
-40
0
40
80
PROPOSED LAKE LEVEL = 806.0
W.L.
CLAY
840
800
760
-160
-120
-80
-40
0
40
80
120
PROPOSED LAKE LEVEL = 806.0
W.L.
A
860
820
780
-80
-40
0
40
80
120
160
200
DRILL HOLE 9-1
FENCE
PROPOSED LAKE LEVEL = 806.0
W.L.
ROCK
A
CI Wn = 28.4
CI Wn = 29.7
CL Wn = 26.8
LL = 28.3
P.L. = 16.8


CROSS SECTION NO. 7
NAPPLICABLE BECAUSE OF NO BEDROCK
LEVEL = 806.0
DRILL HOLE 7-1
HOUSE
3/4"ø PIN TOP ELEV.=813.91
A
CLAY
CI Wn = 29.3
CI Wn = 31.9 L.L.=45.2 P.L.=22.4
CI Wn = 37.3 L.L.=37.4 P.L.=19.9
-80
-40
0
40
80
120
160
200
240
280
320
360
400
440
DISTANCE FROM EDGE OF WATER (FEET)


CROSS SECTION NO. 8
S CROSS SECTION RESULTS IN ALMOST
TH LAKE ELEV. = 806.0, AND COMPLETE
310.0
PPLICABLE.
LAKE LEVEL = 806.0
HOUSE
A
3/4"ø PIN TOP ELEV.= 807.58
-40
0
40
80
120
160
200
240
280
320
360
400
440
480
DISTANCE FROM EDGE OF WATER (FEET)


CROSS SECTION NO. 9
806.0
FENCE
DRILL HOLE 9-1
HOUSE
3/4"ø PIN TOP ELEV.= 846.5
HOUSE
A
B
CI Wn = 28.4
CI Wn = 29.7
CL Wn = 26.8 L.L. = 28.3 P.L. = 16.8
40
80
120
160
200
240
280
320
360
400
440
480
520
560
DISTANCE FROM EDGE OF WATER (FEET)

CROSS SECTION LEGEND

PROFILE AS SURVEYED JULY 1973

—A—o—A— EVENTUAL PROFILE AFTER EROSION AND SLIDING ASSUMING HYPOTHESIS 'A'

—B—o—B— EVENTUAL PROFILE AFTER EROSION AND SLIDING ASSUMING HYPOTHESIS 'B'

SOIL LEGEND

☰	ORGANIC	▥	SILT
▨	CLAY	░	SAND
//////	POSSIBLE BEDROCK	///≡///	BEDROCK OUTCROP

NOTE: ALL ELEVATIONS BASED ON WATER SURVEY OF CANADA BENCH MARK LOCATED ADJACENT TO MANITOBA GOVERNMENT DOCK AND HAVING ELEVATION OF 786.45 G.S.C.

NOTE: FOOT PRINT LAKE ELEVATION AT TIME OF SURVEY IS 783.5.

FIG. 5-3

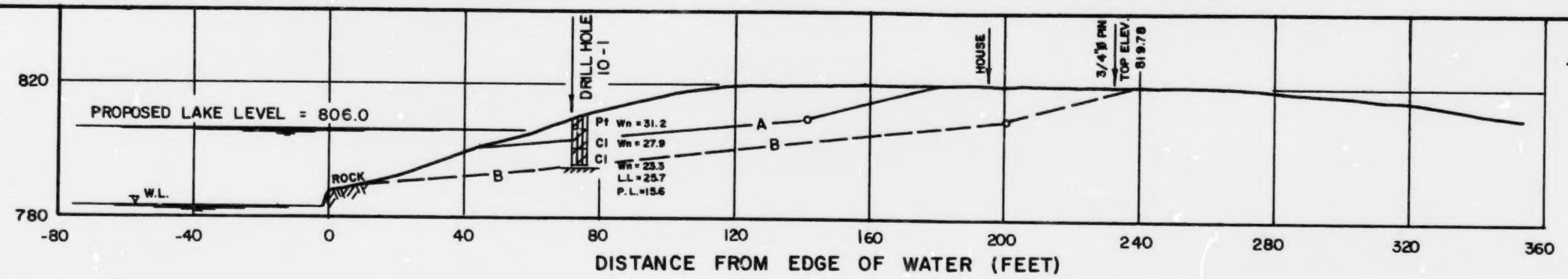
PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH
PREPARED F.P.
DRAWN D.K.
CHECKED
SUBMITTED A Payne
DATE
APPROVED
DATE

CANADA - MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

NELSON HOUSE SETTLEMENT
SHORELINE INVESTIGATION
CROSS SECTION NO. 7, 8 & 9

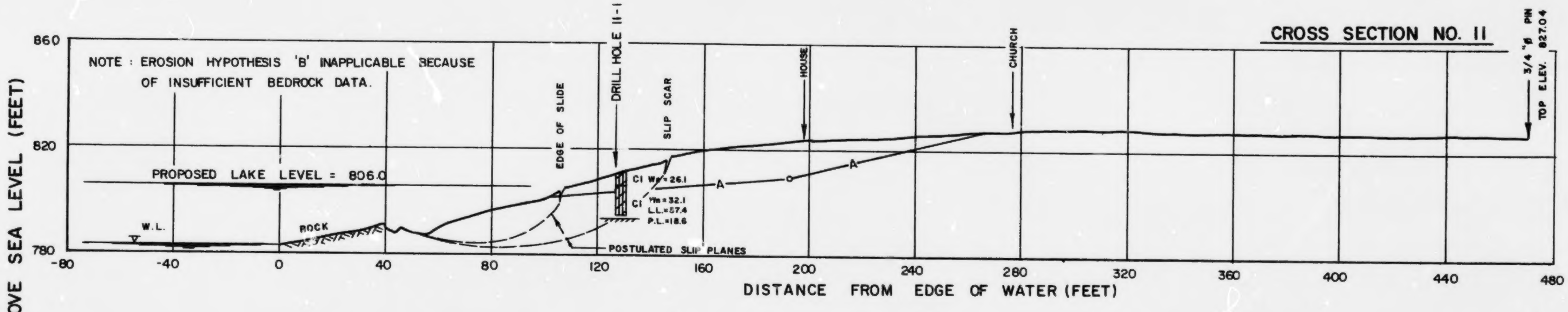
SCALE AS SHOWN
DATE JAN 1975
SHEET 8 OF 10
FILE NO. 57-1-1004

CROSS SECTION NO. 10



820
780
PROPOSED LAKE LEVEL = 806.0
W.L.
ROCK
DRILL HOLE 10-1
Pt Wn = 31.2
Cl Wn = 27.9
Cl Wn = 23.3
L.L = 25.7
P.L. = 15.6
A
B
HOUSE
3/4"Ø PIN TOP ELEV. 819.78
-80
-40
0
40
80
120
160
200
240
280
320
360
DISTANCE FROM EDGE OF WATER (FEET)

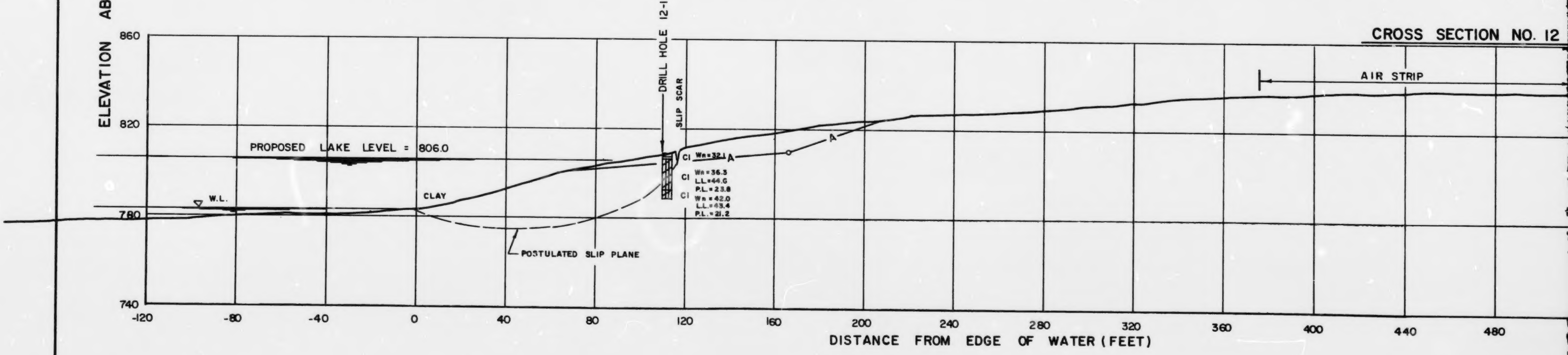
CROSS SECTION NO. 11



ELEVATION ABOVE SEA LEVEL (FEET)
860
820
780
NOTE : EROSION HYPOTHESIS 'B' INAPPLICABLE BECAUSE OF INSUFFICIENT BEDROCK DATA.
PROPOSED LAKE LEVEL = 806.0
W.L.
ROCK
EDGE OF SLIDE
DRILL HOLE 11-1
SLIP SCAR
HOUSE
CHURCH
3/4"Ø PIN TOP ELEV. 827.04
Cl Wn = 26.1
Cl Wn = 32.1
L.L. = 57.4
P.L. = 18.6
A
POSTULATED SLIP PLANES
-80
-40
0
40
80
120
160
200
240
280
320
360
400
440
480
DISTANCE FROM EDGE OF WATER (FEET)

NOTE : I.

CROSS SECTION NO. 12



860
820
780
740
AIR STRIP
PROPOSED LAKE LEVEL = 806.0
W.L.
CLAY
DRILL HOLE 12-1
SLIP SCAR
Cl Wn = 32.1
A
Cl Wn = 36.3
L.L. = 44.6
P.L. = 23.8
Cl Wn = 42.0
L.L. = 43.4
P.L. = 21.2
POSTULATED SLIP PLANE
-120
-80
-40
0
40
80
120
160
200
240
280
320
360
400
440
480
DISTANCE FROM EDGE OF WATER (FEET)

PROVINCE OF MANITOBA

DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTA

WATER RESOURCES BRA

PREPARED	DRAWN D.K.	SUBMITTED
F.P.	CHECKED	DATE

OSS SECTION NO. 10

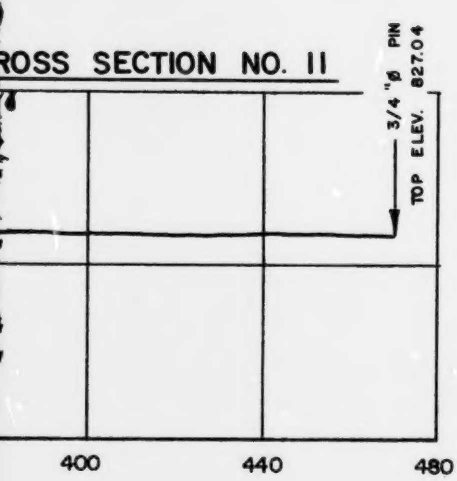
CROSS SECTION LEGEND

- PROFILE AS SURVEYED JULY 1973
- —A—o—A— EVENTUAL PROFILE AFTER EROSION AND SLIDING ASSUMING HYPOTHESIS 'A'
- —B—o—B— EVENTUAL PROFILE AFTER EROSION AND SLIDING ASSUMING HYPOTHESIS 'B'

SOIL LEGEND

☰	ORGANIC	▥	SILT
▨	CLAY	░	SAND
⫽⫽⫽	POSSIBLE BEDROCK	///≡///	BEDROCK OUTCROP

NOTE : 1. ALL ELEVATIONS BASED ON WATER SURVEY OF CANADA BENCH MARK LOCATED ADJACENT TO MANITOBA GOVERNMENT DOCK AND HAVING ELEVATION OF 786.45 G.S.C.
2. FOOT PRINT LAKE ELEVATION AT TIME OF SURVEY IS 783.5


ROSS SECTION NO. 11

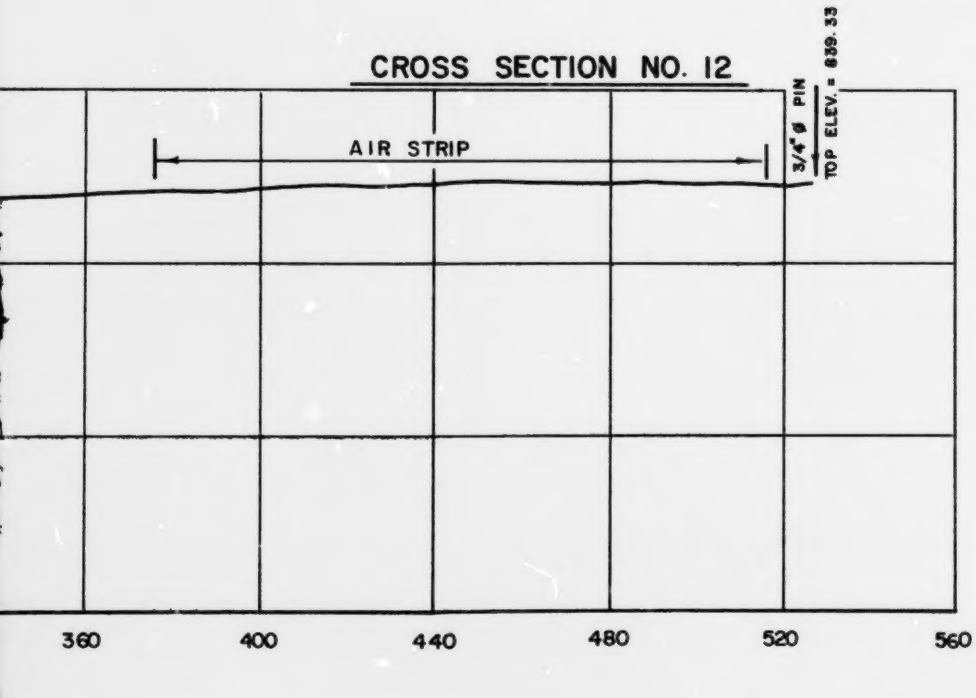
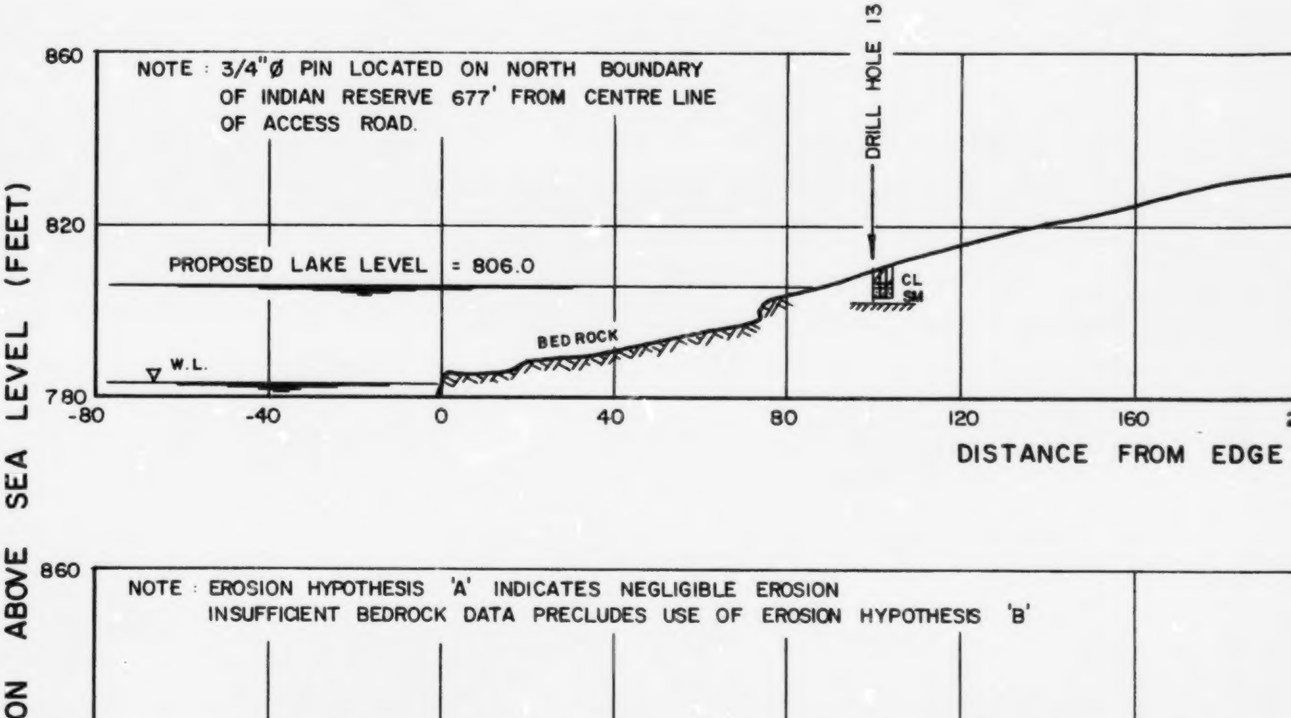
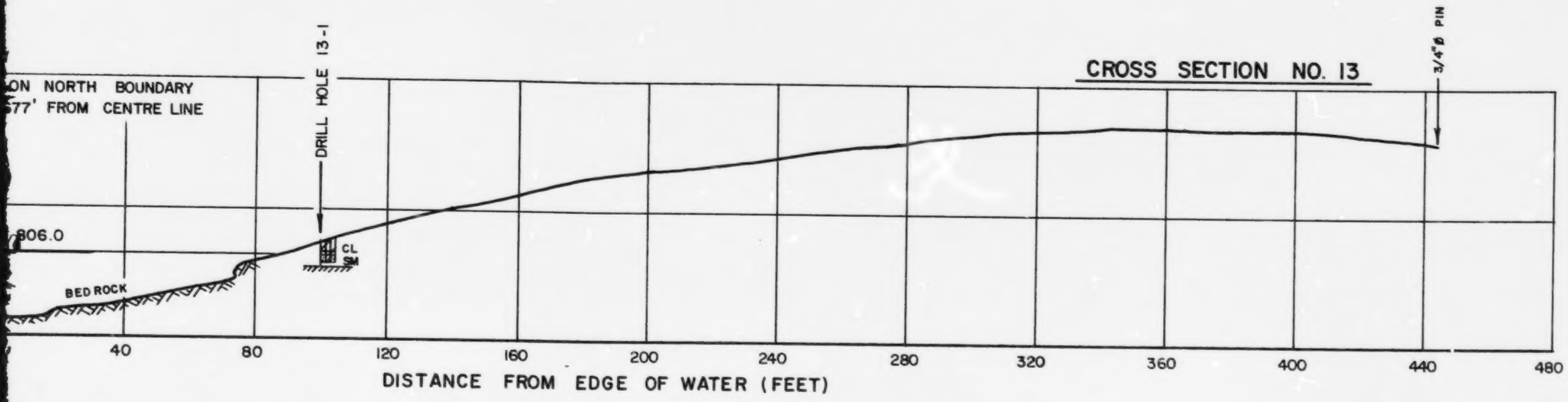

CROSS SECTION NO. 12

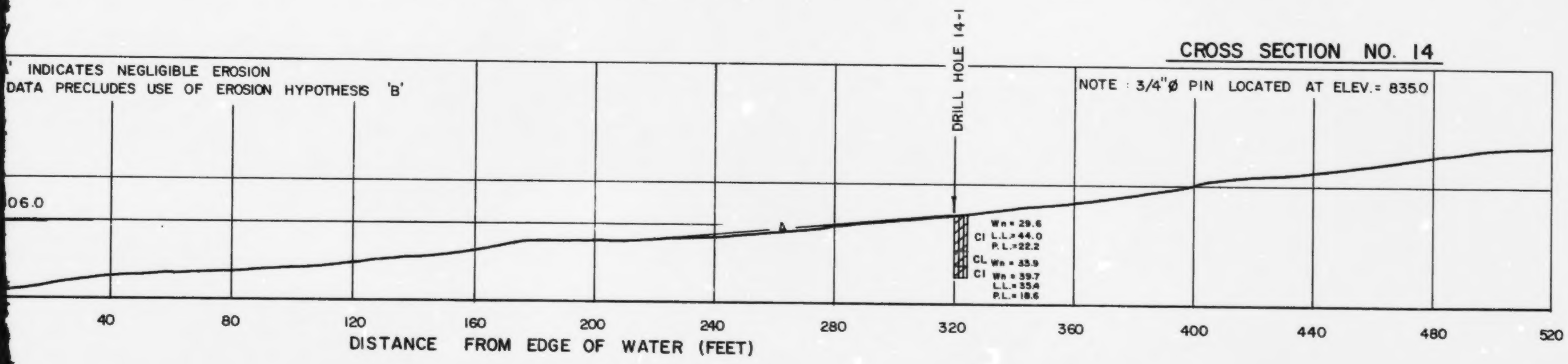
FIG. 5-4

PROVINCE OF MANITOBA DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT WATER RESOURCES BRANCH	CANADA - MANITOBA LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD NELSON HOUSE SETTLEMENT SHORELINE INVESTIGATION CROSS SECTION NO. 10, 11 & 12

PREPARED	DRAWN	SUBMITTED	APPROVED	SCALE	DATE	SHEET	FILE NO.
F.P.	D.K.	F. Penner	E. Mundy	AS SHOWN	JAN. 1975	9 of 10	57-1-1004
	CHECKED	DATE	DATE				


ELEVATION ABOVE SEA LEVEL (FEET)
860
820
780
-80
-40
0
40
80
120
160
DISTANCE FROM EDGE
NOTE : 3/4"Ø PIN LOCATED ON NORTH BOUNDARY OF INDIAN RESERVE 677' FROM CENTRE LINE OF ACCESS ROAD.
DRILL HOLE 13-1
PROPOSED LAKE LEVEL = 806.0
W.L.
BED ROCK
CL
SM
NOTE : EROSION HYPOTHESIS 'A' INDICATES NEGLIGIBLE EROSION
INSUFFICIENT BEDROCK DATA PRECLUDES USE OF EROSION HYPOTHESIS 'B'
PROPOSED LAKE LEVEL = 806.0
W.L.
DISTANCE FROM EDGE


CROSS SECTION NO. 13
ON NORTH BOUNDARY
77' FROM CENTRE LINE
DRILL HOLE 13-1
3/4"ø PIN
806.0
BED ROCK
CL
SM
40
80
120
160
200
240
280
320
360
400
440
480
DISTANCE FROM EDGE OF WATER (FEET)


CROSS SECTION NO. 14
' INDICATES NEGLIGIBLE EROSION
DATA PRECLUDES USE OF EROSION HYPOTHESIS 'B'
DRILL HOLE 14-1
NOTE : 3/4"ø PIN LOCATED AT ELEV.= 835.0
06.0
A
CI
Wn = 29.6
L.L.= 44.0
P.L.= 22.2
CL
Wn = 33.9
CI
Wn = 39.7
L.L.= 35.4
P.L.= 18.6
40
80
120
160
200
240
280
320
360
400
440
480
520
DISTANCE FROM EDGE OF WATER (FEET)

CROSS SECTION LEGEND

PROFILE AS SURVEYED JULY 1973

—A—o—A EVENTUAL PROFILE AFTER EROSION AND SLIDING ASSUMING HYPOTHESIS 'A'

—B—o—B EVENTUAL PROFILE AFTER EROSION AND SLIDING ASSUMING HYPOTHESIS 'B'

SOIL LEGEND

☰	ORGANIC	▥	SILT
▨	CLAY	░	SAND
⊤⊤⊤⊤	POSSIBLE BEDROCK	///≡///	BEDROCK OUTCROP

NOTE : ALL ELEVATIONS BASED ON WATER SURVEY OF CANADA BENCH MARK LOCATED ADJACENT TO MANITOBA GOVERNMENT DOCK AND HAVING ELEVATION OF 786.45 G.S.C.

NOTE : FOOT PRINT LAKE ELEVATION AT TIME OF SURVEY IS 783.5

FIG. 5-5

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

PREPARED F.P.
DRAWN D.K.
CHECKED
SUBMITTED
DATE
APPROVED
DATE

CANADA - MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

NELSON HOUSE SETTLEMENT
SHORELINE INVESTIGATION
CROSS SECTION NO. 13 & 14

SCALE AS SHOWN
DATE JAN 1975
SHEET 10 OF 10
FILE NO. 57-1-1004

SHORELINE EROSION AT
LAC DU BONNET AND PINE FALLS RESERVOIRS
WINNIPEG RIVER, MANITOBA

An information appendix for reports on the effects of raised water levels on the shorelines at South Indian Lake and Nelson House Communities.

by

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Department of Civil Engineering
University of Manitoba
Winnipeg, Manitoba
August, 1973

sub-contracted by:

Water Resources Branch
Manitoba Department of Mines, Resources and Environmental Management
Winnipeg, Manitoba

for

THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

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6	Graph of Shelf Width Vs. Elapsed Time for Lac du Bonnet Erosion	27

ABSTRACT

As part of the impact studies of the Churchill River Diversion Projects, the effects of the proposed raised water levels are being studied at Nelson House, and South Indian Lake communities. At these sites, extensive portions of the raised shoreline will consist of cohesive clays and silty clays of glacial lake origin. Because of the lack of published information on shoreline development in such soils, the decision was made to study the Pine Falls and Lac du Bonnet reservoirs where soils of similar geological origin have been subjected to raised water levels since 1951 and 1955 respectively.

This report summarizes data obtained from Manitoba Hydro, the Water Resources Branch of the Province of Manitoba, and from actual visits to the two reservoirs. The report is intended as an appendix to reports being prepared regarding Nelson House and South Indian Lake respectively. The latter reports will contain the interpretation of the data regarding the northern sites. The study of the Lac du Bonnet and Pine Falls reservoirs shows how erosion develops, and how it can be controlled by rip-rap.

INTRODUCTION

This report is an appendix to reports being prepared on the effects of raised river and lake levels at Nelson House and South Indian Lake communities due to planned diversion of the Churchill into the Nelson via the Rat-Burntwood River System. The report consists of a compilation of data to which reference can be made in the main reports. The data were obtained from Manitoba Hydro and the Water Resources Branch of the Manitoba government, to whom grateful acknowledgements are made. Additional information was obtained from actual visits to reservoirs during July, 1973.

The interpretation of data is mainly left to the main reports where conditions can be compared or contrasted to those at Nelson House and South Indian Lake.

RELEVENCE OF DATA AS IT APPLIES TO NELSON HOUSE AND SOUTH INDIAN LAKE

It will be seen from Figure 1, that the Pine Falls and Lac du Bonnet reservoirs, are situated in areas of extinct glacial lakes, as are the communities of Nelson House and South Indian Lake. Figure 2 shows the Pine Falls and Lac du Bonnet reservoirs in enlarged detail. Figure 1 shows the results of one set of borings at Lac du Bonnet. From field testing currently underway, it is evident that similar soils occur at a number of sites at the northern locations. The soils include cohesive clays and silty clays for which very little published information is available regarding shoreline erosion. The data from Pine Falls and Lac du Bonnet reservoirs show the effects of 22 and 18 years respectively of raised water levels on shoreline consisting of these cohesive soils. However, use of the data requires full consideration of such factors as topography, ice thickness, water level fluctuations, waves, permafrost occurrence, location of bedrock, etc., considered in the main reports. For the purpose of the main reports, Figure 3 shows contours of mean annual temperatures.

EROSION HISTORY OF PINE FALLS AND LAC DU BONNET RESERVOIRS

The dam at Pine Falls was completed in 1951. Preceeding the construction of the dam, the average flow in the Winnipeg River was about 26,000 cfs and the water level was at elevation 725. After the completion of the dam the water level was raised to elevation 752, thus creating an increase in water level of 27 feet in the vicinity of St. George.

In 1954, a dam was built at MacArthur Falls, downstream of Lac du Bonnet. This had the effect of raising the water level by 16 feet from about elevation 820 to elevation 836 at Lac du Bonnet.

The major fluctuations in both reservoirs occur on a daily basis and then the change in water level is only about one foot. The reservoirs are used for pondage only, and not storage, hence no large annual fluctuations.

Dykes, dock and certain other key areas received rip-rap protection right from the start. In other areas, it has been the policy to note where erosion has been taking place. Rip-rap is then placed when and where required. (The formation of an erosion ledge on the bank at the water's edge simplifies where to place the rip-rap.) Manitoba Hydro records indicate that about one cubic yard of rip-rap per lineal foot of shoreline has provided adequate protection.

TABLE 1

FLOW CHARACTERISTICS FOR THE WINNIPEG RIVER AT LAC DU BONNET AFTER DEVELOPMENT

1971	Peak Elevation	837.2'	CGS
1971	Minimum Elevation	835.2'	CGS
1971	Mean Flow	44,100	CFS
1971	Maximum Daily Flow	70,800	CFS on Dec. 14
1971	Minimum Daily Flow	17,600	CFS on Sept. 12
Recorded Maximum Daily Flow		98,800	CFS on June 30, 1954
Recorded Minimum Daily Flow		9,200	CFS on Sept. 6, 1958

EROSION RECORDS

Manitoba Hydro has maintained records of those areas showing more rapid erosion in anticipation of when protective action would be required. (It must be noted this produces information biased towards worst rather than average conditions.) Figure 2 shows the location of 11 cross-sections at 9 different sites where erosion information was available. These cross-sections have been shown in Figure 4A, 4B, 4C, and 4D. Shown on these figures are the present profiles of the bank, obtained from recent surveys and underwater soundings, and reconstruction of the original profiles, and profiles at intermediate times obtained from surveys made on the dates shown. The intermediate profiles involve some approximation, as survey data required interpolation to establish such boundaries as the water's edge and top of the slide area. None of the cross-sections shown have had rip-rap protection.

In general, the eroded banks consist of the finer soils where bedrock outcrop does not occur at the water's edge. A shelf tends to form on the newly submerged portion of the bank at a point where the bank is about 5 feet below the water surface. This "shelf" itself has a very flat slope of about 5 degrees from the horizontal and rising towards the shore. "Shelf" widths of between 50 to 110 feet have developed in the 18 to 22 years of inundation. Figure 5, schematically shows how the height of the bank above the water edge is a factor governing how much the bank will be affected by sliding. High steep banks will be more affected by sliding than low slopes. (Compare Photographs 1 and 2.) Erosion of the low banks however, may produce a wider shelf in a shorter time. With low banks, less slide debris is available because there is less material from above to slide onto the shelf. Consequently, erosion concentrates or widening the shelf rather then on having to remove slide debris. This may be the reason for the wide shelf of Cross-Section 3, shown in Figure 4A.

An anomaly appears in Cross-Section 7 of Figure 4c. The "shelf" development evident in all 10 other cross-sections apparently has not taken place at Cross-Section 7. Photograph 5 offers a possible explanation. There appears to be a ridge along which the original survey was made. A trace of this ridge is represented by the high point in the exposed slide plane. The section is located where the Winnipeg River flow may have eroded the ridge underwater, leaving only a small shelf. Another possible explanation is that because of the uneven nature of the bank, information for reconstructing the original profile does not match subsequently obtained data.

DISCUSSION OF PHOTOGRAPHS

Photographs 1 and 2 show how the differences in height of bank above the water's edge affect sliding. Much more slide debris is involved in the case of higher bank in Photograph 1. Cohesive soil slopes can be stable over short periods of time with steep slopes. Long term stability however, requires less steep slopes. The initial sliding exposes a steep sliding plane. With time, the upper portions of the exposed slope undergo movement so as to develop the less steep slopes consistent with long term stability. This process is shown in Photographs 1, 5, and 12. In Photograph 12, the adjustment of the upper portions of the slope has continued after the placing of the rip-rap which has stopped erosion.

Photograph 3 shows different stages of removal of slide debris by erosion. It also illustrates one of the problems of obtaining representative cross-sections at any given time. The bank at the center of the photo has more exposed slide plane then are shown on either side.

Photograph 4 illustrates that banks with trees can be affected by the sliding initially commenced by erosion. Photograph 5 as well as photographs 1, 2, 3, 6, 8, 9, and 10 have been included to show the bank appearance at locations of cross-sections. In the case of photographs 6 and 7, shoreline where bedrock controls the new shoreline is shown. Photographs 8, 9, and 10 contrast rip-rap protected banks, (shown on the left side of the photographs), with portions not protected, (shown on the right). Photograph 11 shows the man-made beach, and dock constructed at Lac du Bonnet.

RATE OF BANK RECESSION

The rate of bank recession is highly variable and dependent upon several factors:

1. bank material,
2. orientation of the shoreline to prevailing wind direction and the height of waves from this direction,
3. shoreline slope,
4. vegetation cover,
5. changing water levels,
6. groundwater conditions, and
7. the placing or removal of protective cover.

From an inspection of the shoreline along the two reservoirs it would appear that the action of waves is the dominant factor causing bank recession. Analysis of the rate of formation of the shelf width was made by Mr. D. Andres of the Manitoba Water Resources Branch. The results are shown in a plot of the shelf width versus time, (Figure 6). This plot indicates width is still increasing with time, but at an apparently decreasing rate. In other words, the shoreline in many places has not stablized. It is difficult to predict the final position of the bank but the erosion should not continue indefinitely. As the width of the shelf increases the approaching waves will have an increasing portion of their energy dissipated on the shelf and the shoreline will slowly stablize. Relationships relating shelf height and shelf width for stable shelf slopes have been developed for reservoirs in Russia (Kondratjev, 1966)[1], but these are difficult to apply to the Winnipeg River reservoirs as the listed coefficients are for granular, non-cohesive bank materials. Recent studies (2, 3) of the bank erosion along Lake Diefenbaker indicate that bank erosion can be fairly rapid. A study of stable slopes along reservoirs throughout Western Canada may be worthwhile, but, to date, no such studies have been undertaken.

---

[1] Kondratjev, N. E. - "Bank Formation of Newly Established Reservoirs", International Association Sci. Hydrology, Symposium Garda, Vol. 2, 1966

In the case of cohesive soils, the rate of bank recession undergoes rapid changes. As the lower face of the bank is worked on by waves and current, material is removed leaving almost vertical "soil cliffs". If the bank is not too high, the cliffs may then be undercut by continued wave action. When sufficient support is removed, the upper material suddenly drops in chunks or blocks. To the observer, this appears as a sudden recession of the top of the bank often involving several or more feet parallel to the shoreline.

For higher banks, the removal of soil to form "cliffs", has a further detrimental effect. When sufficient support is removed, slides of the type shown in Figure 5b take place. The top of the bank undergoes sudden, and often, very large, recession. The process is then repeated as the slide debris is removed by wave and current action.

The abrupt changes in the rate of recession would generally preclude the drawing of smooth curves for the shelf width plotted against time relationship shown in Figure 6 for individual cross-sections.

From an examination of banks where rip-rap has been used it is evident that rip-rap can effectively stop the erosive effect of the waves, and thus prevent subsequent sliding. It is possible that some banks protected by vegetation roots, etc. become more suceptible to wave erosion when these are removed for landscaping or other reasons.

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2. Coakley, J. and Hamblin, P. - "Investigation of Bank Erosion and Nearshore Sedimentation in Lake Diefenbaker", Canada Centre for Inland Waters Report, 1970.

3. Van Everdingen, R. - "Diefenbaker Lake, Effects of Bank Erosion on Storage Capacity", Technical Bulletin No. 10, Inland Waters Branch, Ottawa, 1968.

CONCLUSION

The mechanism of erosion and accompanying sliding of cohesive soils was examined for the Lac du Bonnet and Pine Falls reservoirs. At 10 sites, all having undergone the most severe erosion, the formation of an erosion "shelf" at shallow depth on the newly submerged bank was noted. Above the new water's edge, the banks were affected by sliding. The extent of sliding was greater for high banks than for low ones. Conclusive evidence was available indicating that rip-rap effectively stopped the erosion process. This can be placed subsequent to raising water levels and there is advantage in waiting until sufficient erosion shelf develops to form a supporting ledge for the rip-rap.

PROVINCE OF MANITOBA
ANDREW
BARACOS
REGISTERED EN

Submitted: August 15, 1973

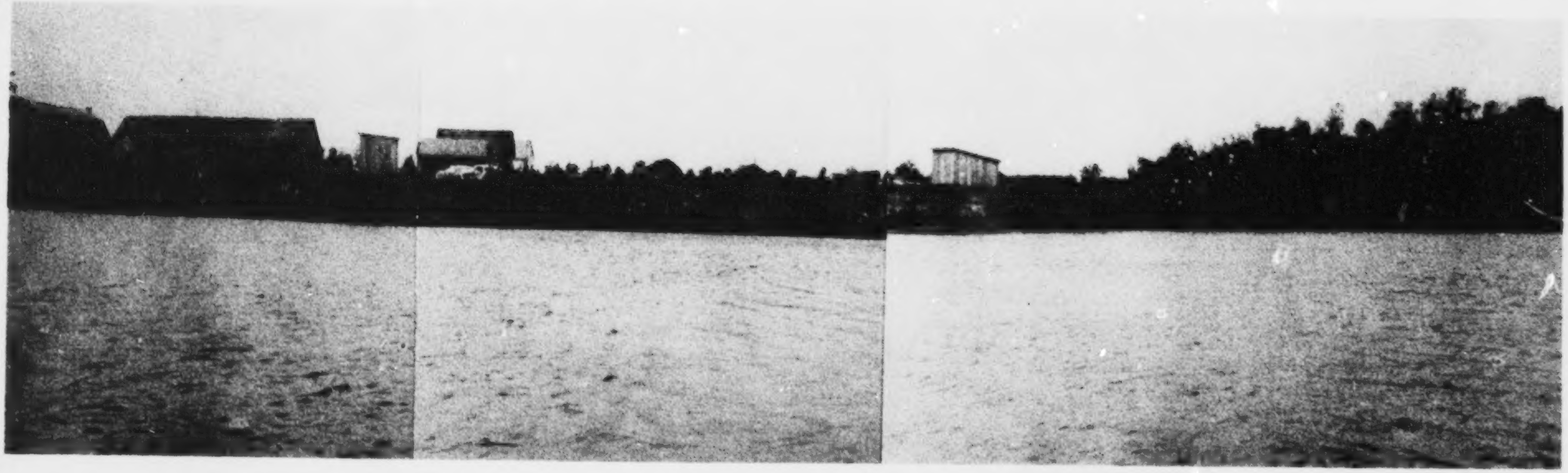
A. Baracos

A. Baracos, P. Eng.

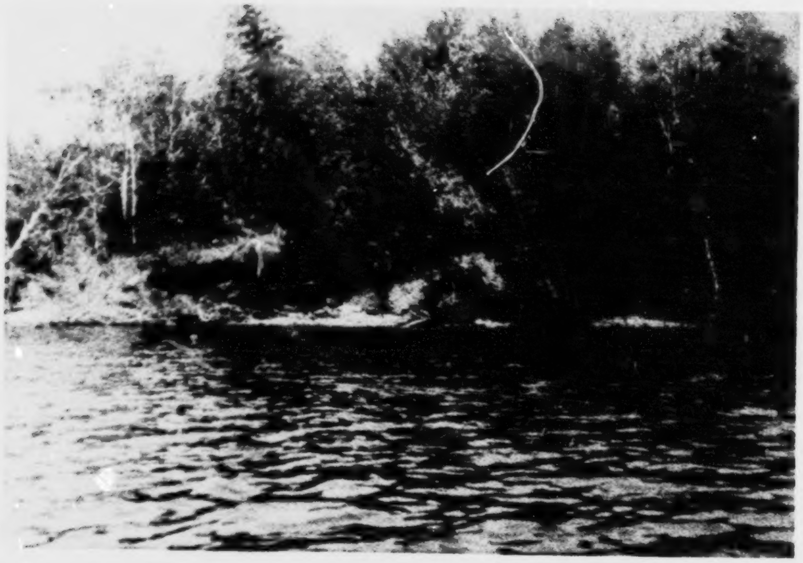
V. Galay, P. Eng.

PHOTOGRAPH 1
SHORELINE EROSION AND SLIDING AT CROSS-SECTION 1
PINE FALLS RESERVOIR
May 1951 to June 1973
Man. Water Resources Photographs 73/120, 14.

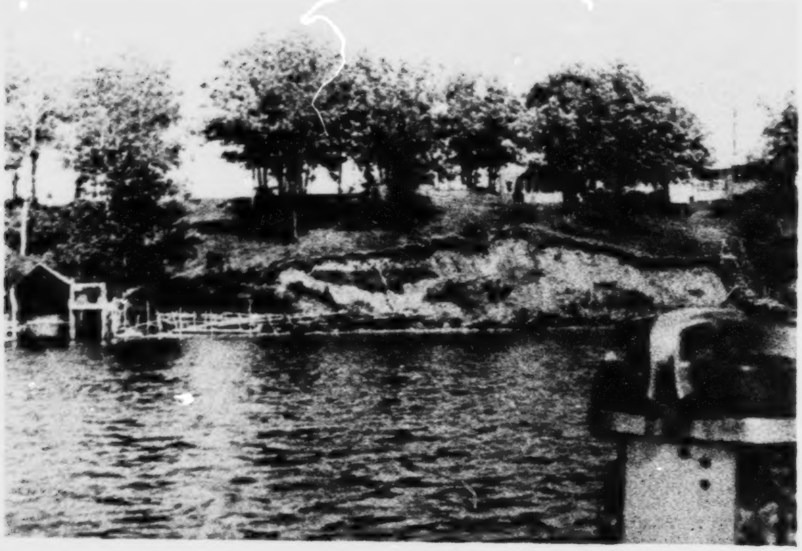
PHOTOGRAPH 2
SHORELINE EROSION AND SLIDING AT CROSS-SECTION 4 AND 5
May 1955 to June 1973
Man. Water Resources Photograph 73/120, 13.



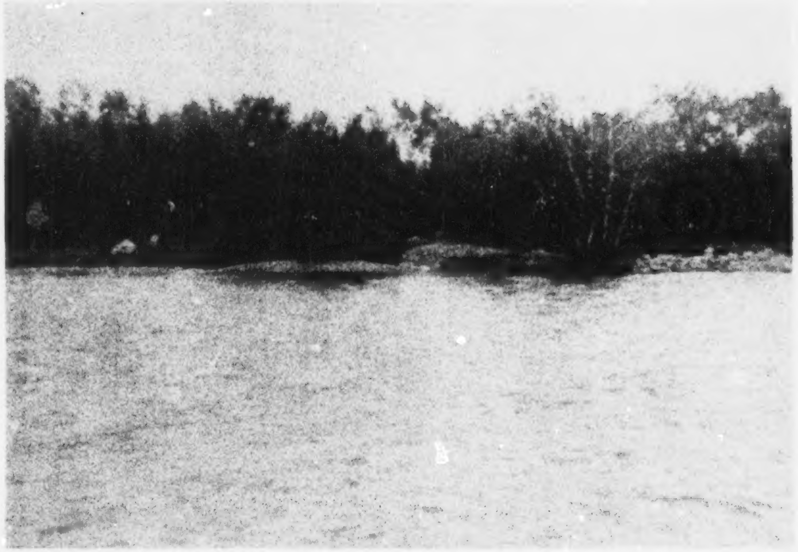
PHOTOGRAPH 3
SHORELINE EROSION AT CROSS-SECTION 3
May 1951 to June 1973
Man. Water Resources Photographs 73/121, 1, 2, and 3.



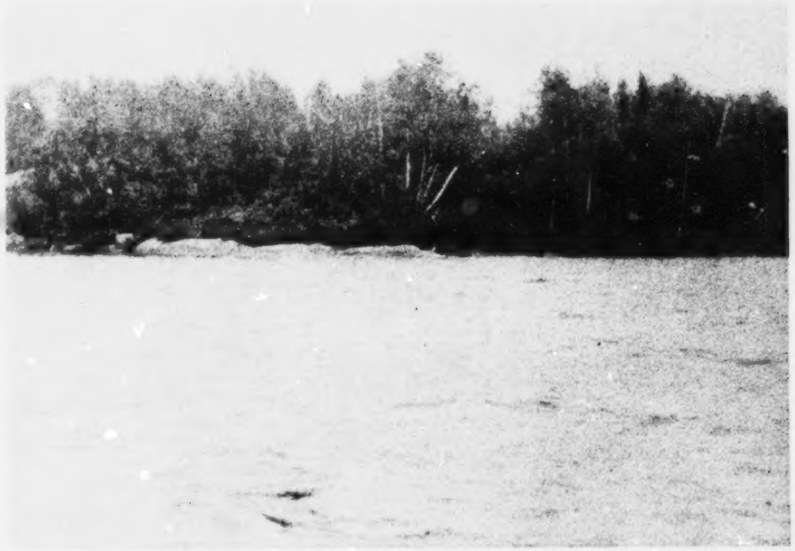
PHOTOGRAPH 4
SHORELINE EROSION AND SLIDING OF BANK WITH TREES
LAC DU BONNET RESERVOIR
May 1955 to June 1973
Man. Water Resources Photograph 73/121, 15.



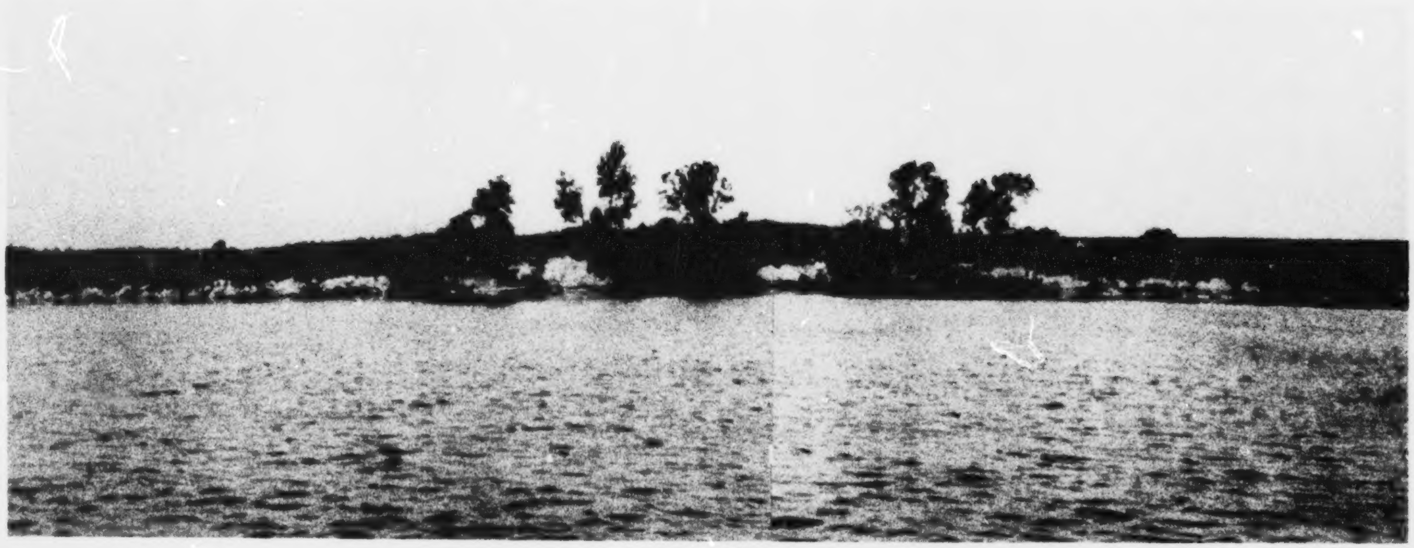
PHOTOGRAPH 5
SHORELINE EROSION AND SLIDING AT CROSS-SECTION 7
LAC DU BONNET RESERVOIR
May 1955 to June 1973
Man. Water Resources Photograph 73/121, 19.



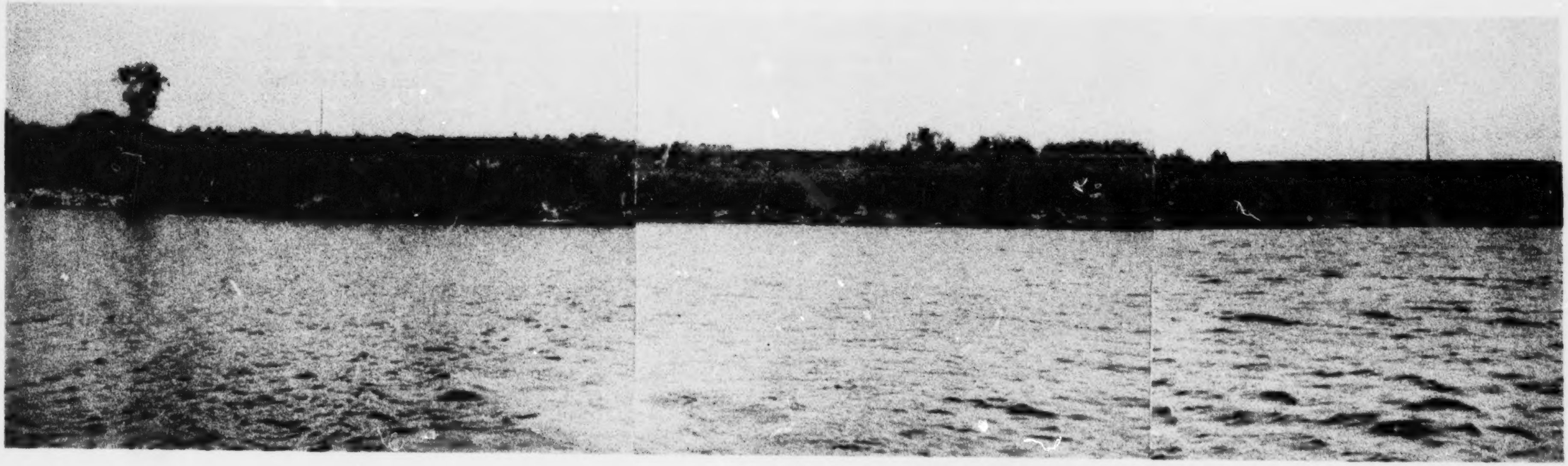
PHOTOGRAPH 6
BEACH DEVELOPMENT AT CROSS-SECTION 8
Man. Water Resources Photograph 73/121, 6
Looking southeast



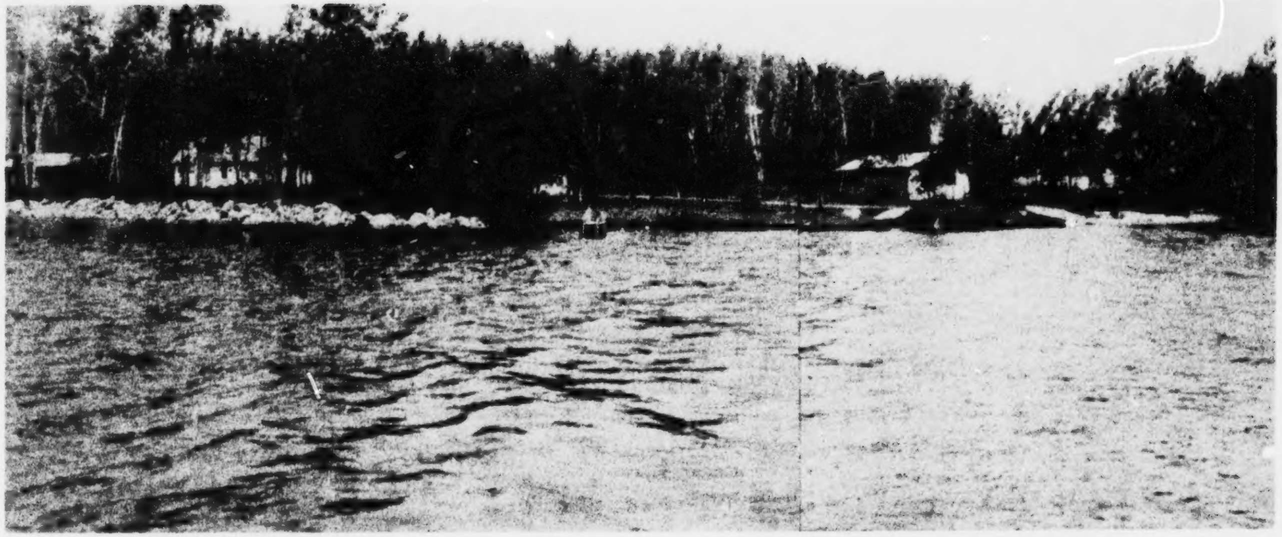
PHOTOGRAPH 7
BEDROCK CONTROL NEAR CROSS-SECTION 8
Man. Water Resources Photograph 73/121, 5
Looking southwest



PHOTOGRAPH 8
SHORELINE PROTECTION AND EROSION AT CROSS-SECTION 9
LAC DU BONNET RESERVOIR
May 1955 to June 1973
Man. Water Resources Photographs 73/121, 10 and 11.



PHOTOGRAPH 9
SHORELINE EROSION AT CROSS-SECTION 10
LAC DU BONNET RESERVOIR
May 1955 to June 1973
Man. Water Resources Photographs 73/121, 12, 13, and 14.

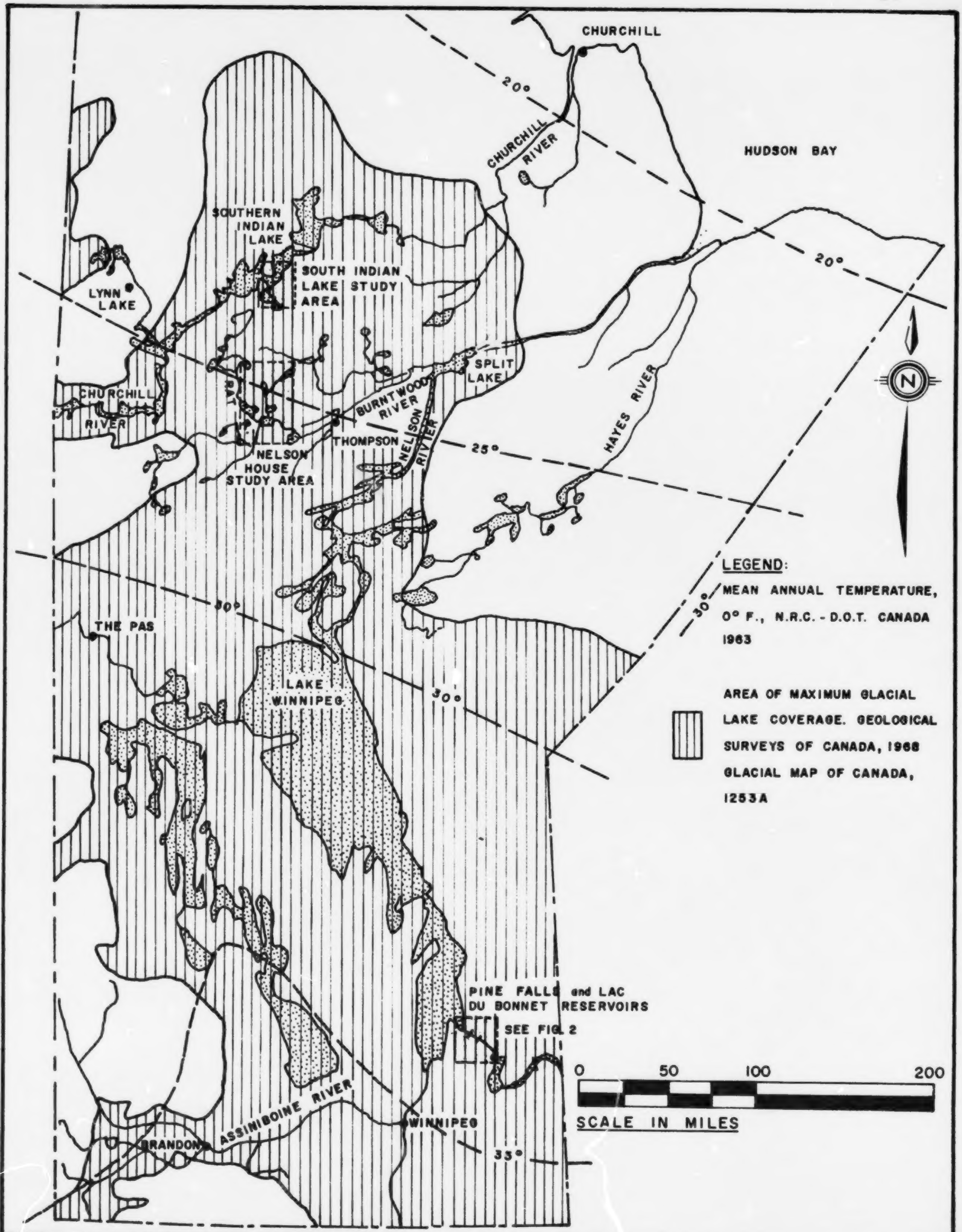


PHOTOGRAPH 10
RIVER BANK EROSION AND RIP-RAP PROTECTION AT CROSS-SECTION 11
LAC DU BONNET RESERVOIR
May 1955 to June 1973
Man. Water Resources Photographs 73/121, 7 and 8.

PHOTOGRAPH 11
DEVELOPED BEACH, AND DOCKING FACILITIES
LAC DU BONNET RESERVOIR
Man. Water Resources Photograph 73/121, 21.

PHOTOGRAPH 12
RIP-RAP PROTECTION OF SLOPE PLACED AFTER EROSION AND SLIDING
NOTE SUBSEQUENT ADJUSTMENT OF UPPER PORTION OF SLIDE SCAR
LAC DU BONNET RESERVOIR

A. Baracos
July 1973


CHURCHILL
20°
CHURCHILL RIVER
HUDSON BAY
SOUTHERN INDIAN LAKE
SOUTH INDIAN LAKE STUDY AREA
LYNN LAKE
20°
SPLIT LAKE
CHURCHILL RIVER
RAT
BURNTWOOD RIVER
NELSON RIVER
THOMPSON
NELSON HOUSE STUDY AREA
25°
HAYES RIVER
N
LEGEND:
MEAN ANNUAL TEMPERATURE, 0° F., N.R.C. - D.O.T. CANADA 1963
30°
AREA OF MAXIMUM GLACIAL LAKE COVERAGE. GEOLOGICAL SURVEYS OF CANADA, 1968 GLACIAL MAP OF CANADA, 1253A
THE PAS
30°
LAKE WINNIPEG
30°
PINE FALLS and LAC DU BONNET RESERVOIRS
SEE FIG. 2
0
50
100
200
SCALE IN MILES
ASSINIBOINE RIVER
BRANDON
WINNIPEG
33°

PROVINCE OF MANITOBA
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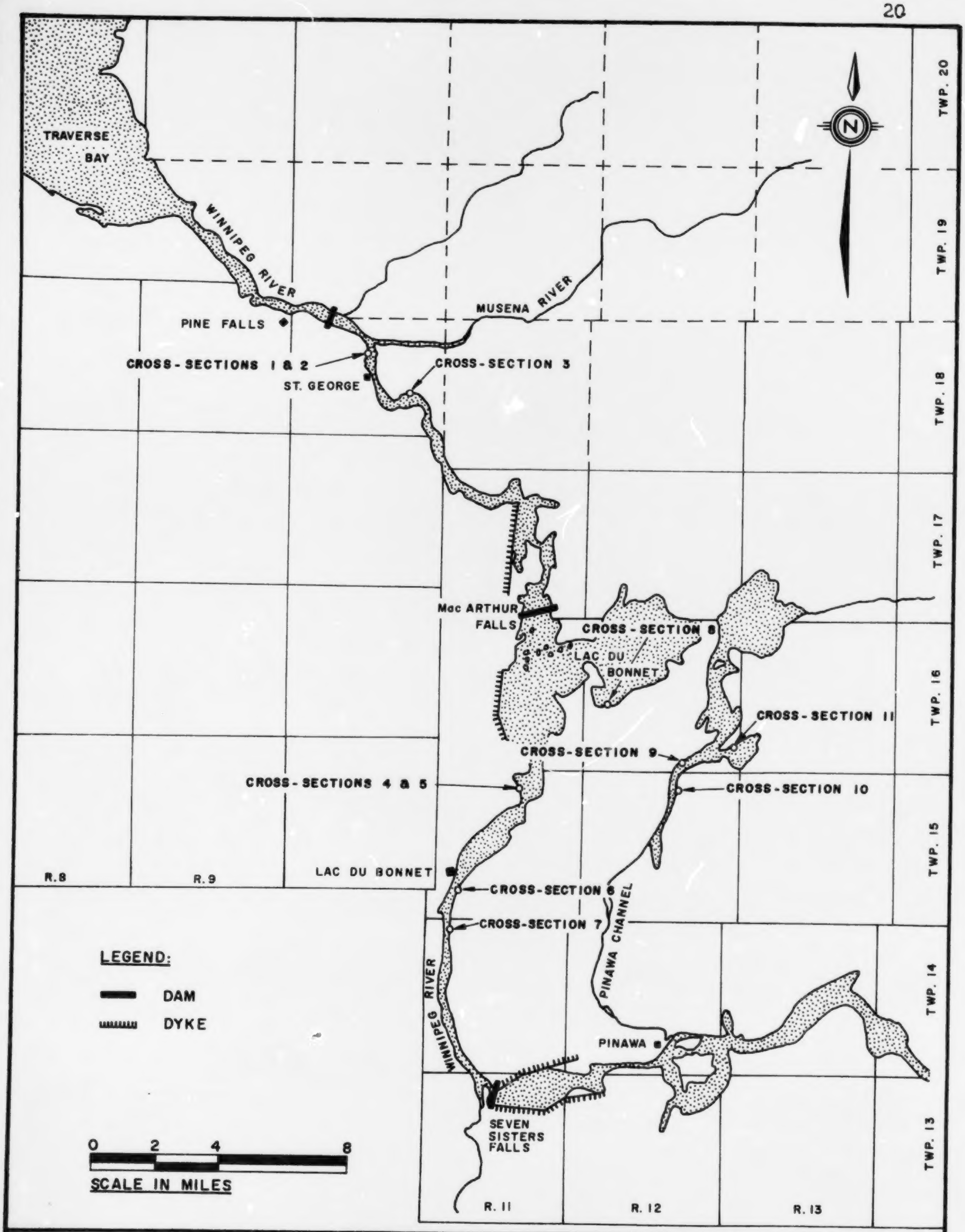
WATER RESOURCES BRANCH
PREPARED DRAWN SUBMITTED APPROVED
CHECKED DATE DATE

CANADA - MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD
SHORELINE INVESTIGATION
FIGURE 1 - LOCATION OF STUDY AREAS
SCALE SHOWN DATE SEP./73 SHEET 1 OF 9 FILE NO. 21-1-1177


TRAVERSE BAY
WINNIPEG RIVER
PINE FALLS
MUSENA RIVER
CROSS-SECTIONS 1 & 2
ST. GEORGE
CROSS-SECTION 3
Mac ARTHUR FALLS
CROSS-SECTION 8
LAC DU BONNET
CROSS-SECTION 11
CROSS-SECTION 9
CROSS-SECTIONS 4 & 5
CROSS-SECTION 10
LAC DU BONNET
CROSS-SECTION 6
CROSS-SECTION 7
PINAWA CHANNEL
WINNIPEG RIVER
PINAWA
SEVEN SISTERS FALLS
LEGEND:
DAM
DYKE
0
2
4
8
SCALE IN MILES
R. 8
R. 9
R. 11
R. 12
R. 13
TWP. 20
TWP. 19
TWP. 18
TWP. 17
TWP. 16
TWP. 15
TWP. 14
TWP. 13
N

PROVINCE OF MANITOBA

DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

WATER RESOURCES BRANCH

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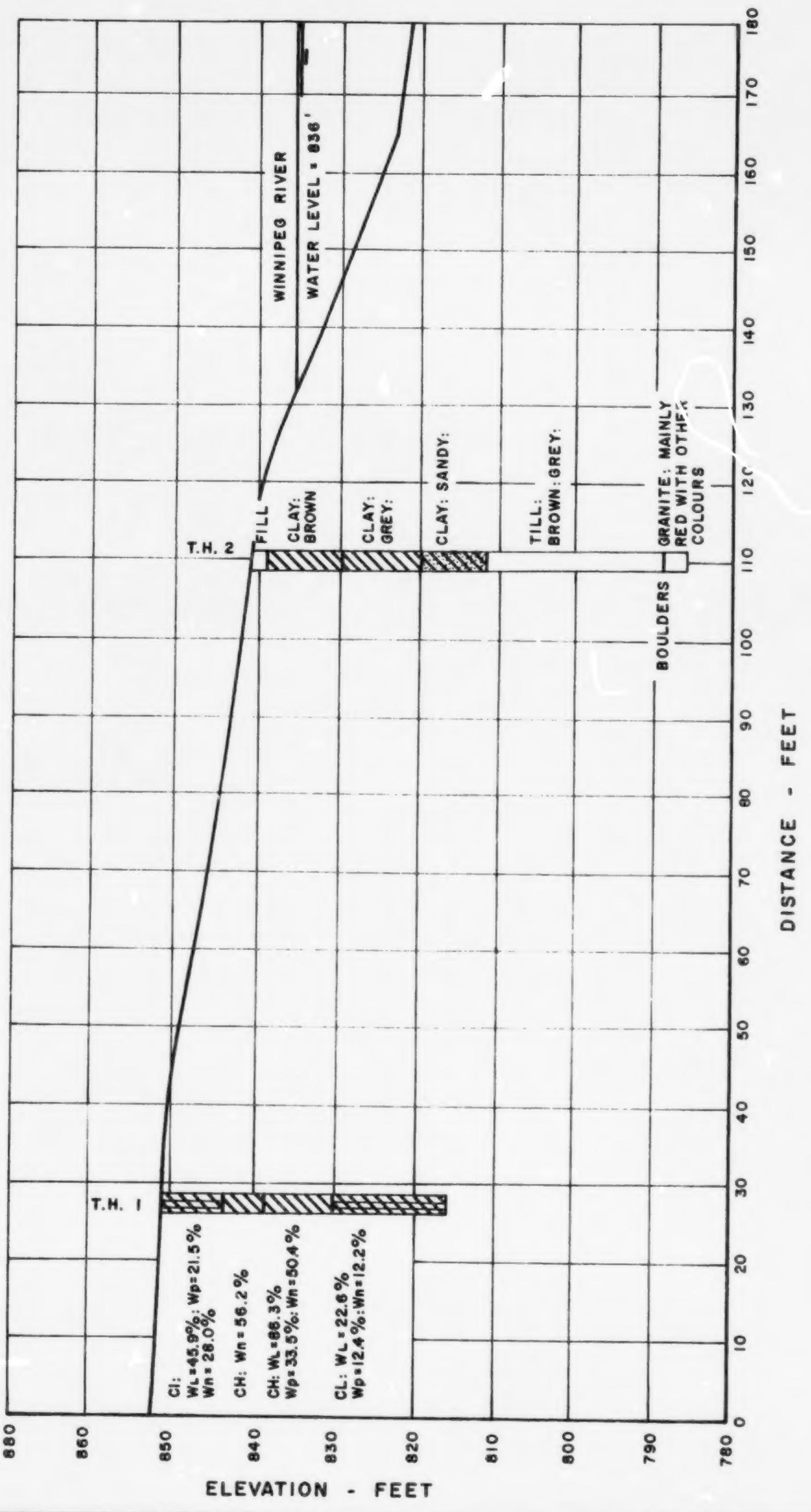
SHORELINE INVESTIGATION

FIGURE 2 - LOCATION OF CROSS-SECTIONS

PREPARED	DRAWN	SUBMITTED	APPROVED
	CHECKED	DATE	DATE

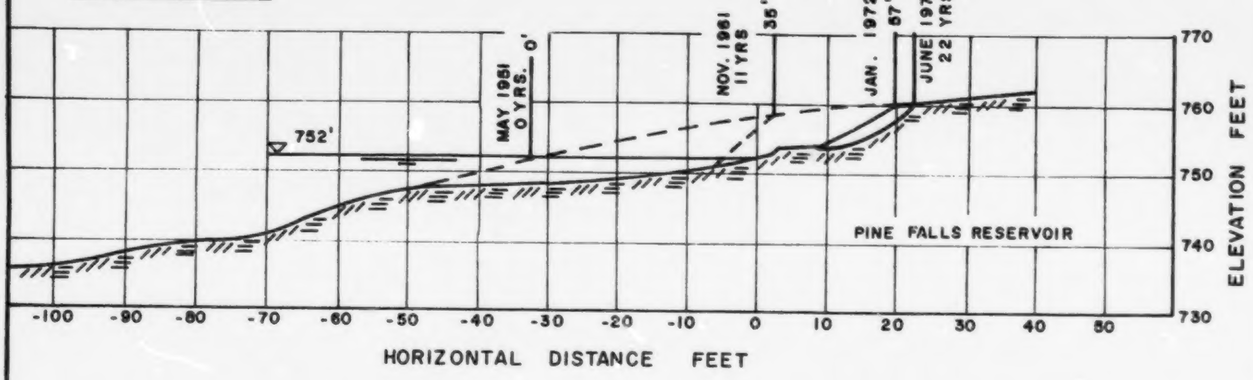
SCALE SHOWN	DATE SEP./73	SHEET 2 OF 9	FILE NO. 21-1-1177



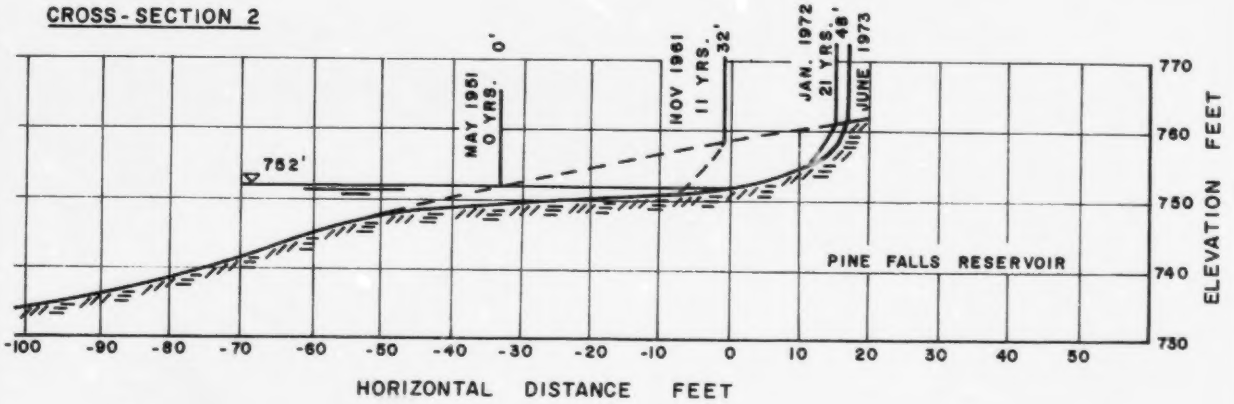
(DRAWING FROM MANITOBA WATER RESOURCES FILE NO. 21-5-1018, MARCH 1973)

PROVINCE OF MANITOBA DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT WATER RESOURCES BRANCH			CANADA - MANITOBA LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD SHORELINE INVESTIGATION FIG. 3 - TEST HOLE DATA LAC DU BONNET PUMPHOUSE
PREPARED	DRAWN CHECKED	SUBMITTED DATE	APPROVED DATE
SCALE SHOWN	DATE SEP./73	SHEET 3 OF 9	FILE NO. 21-1-1177

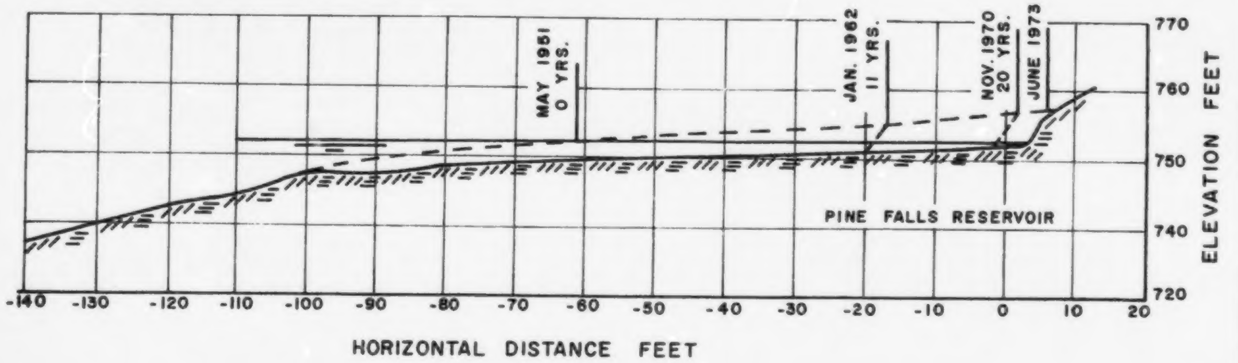
CROSS-SECTION 1



CROSS-SECTION 2



CROSS-SECTION 3



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DATE

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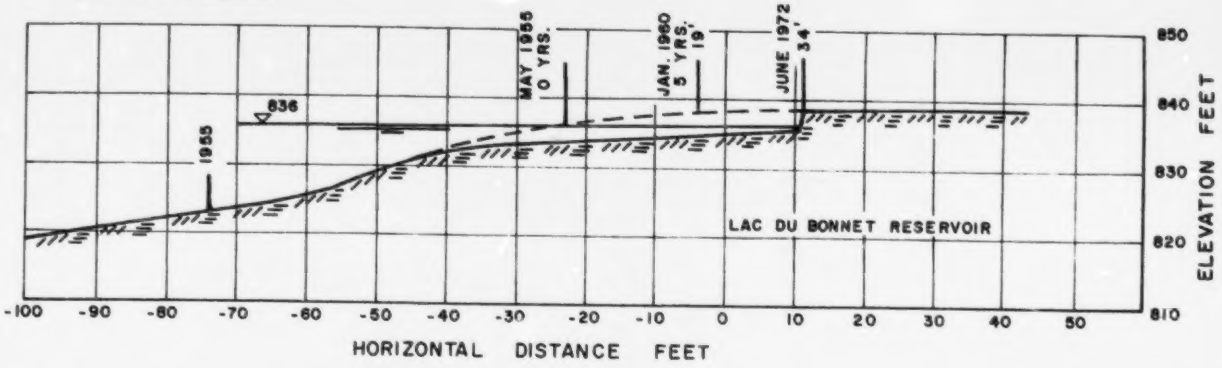
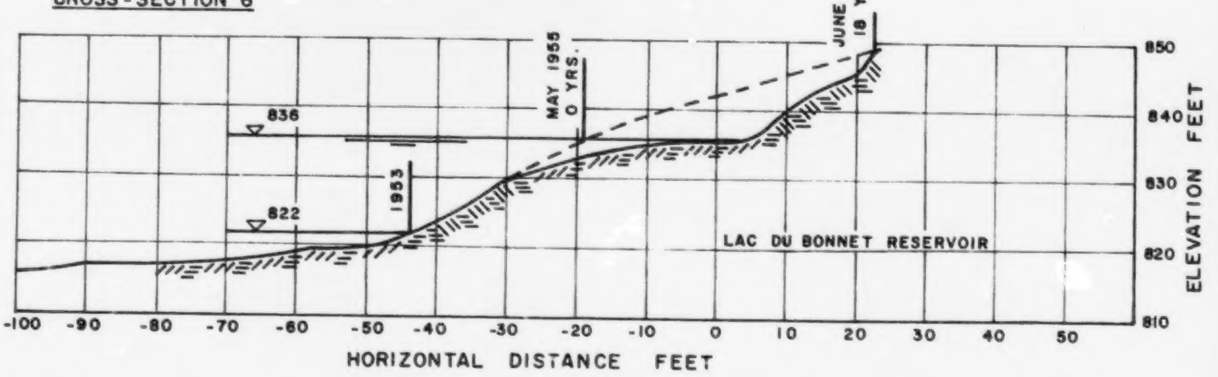
FIG. 4a - EROSION SHELVES ON BANK CROSS-SECTIONS

SCALE SHOWN
DATE SEP./73
SHEET 4 OF 9
FILE NO. 21-1-1177

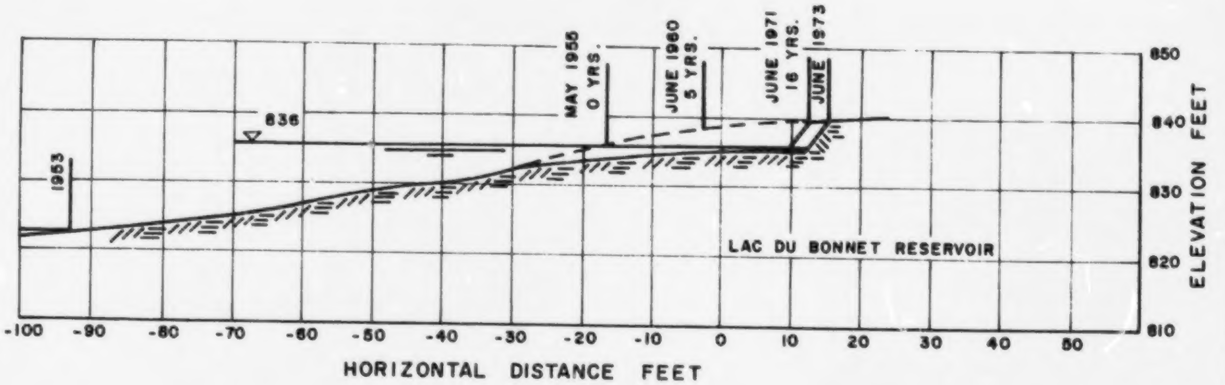
CROSS-SECTION 4



CROSS-SECTION 6



CROSS-SECTION 5



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WATER RESOURCES BRANCH

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	CHECKED	DATE	DATE

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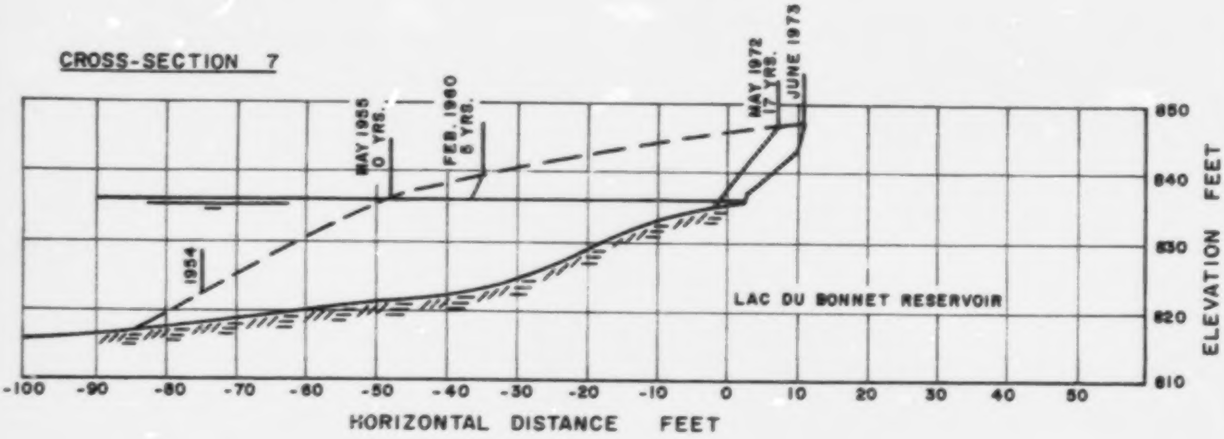
SHORELINE INVESTIGATION

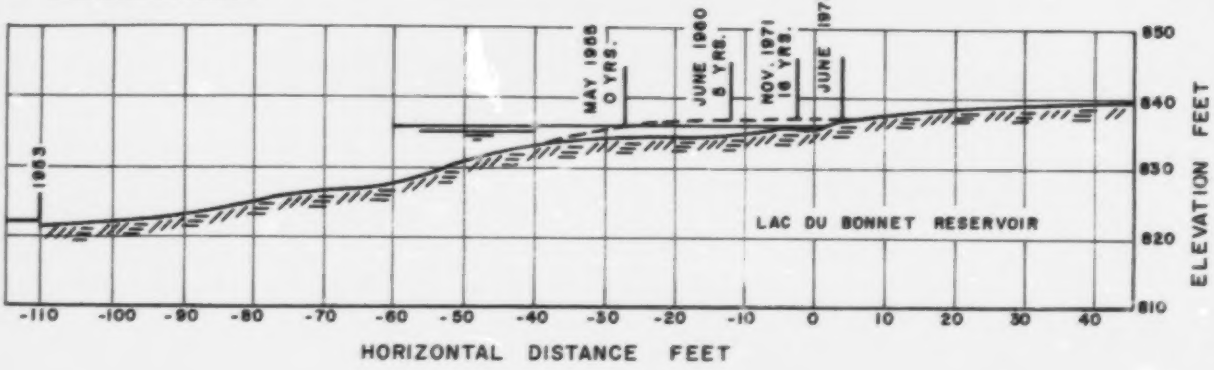
FIG. 4b - EROSION SHELVES ON BANK CROSS-SECTIONS

SCALE SHOWN	DATE SEP./73	SHEET 5 OF 9	FILE NO. 21-1-1177

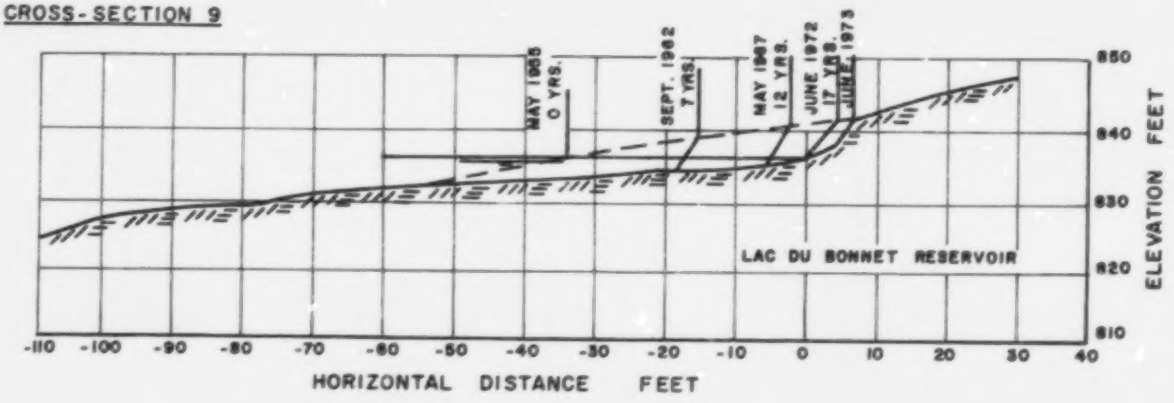
CROSS-SECTION 7



CROSS-SECTION 8



CROSS-SECTION 9



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DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

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	CHECKED	DATE	DATE

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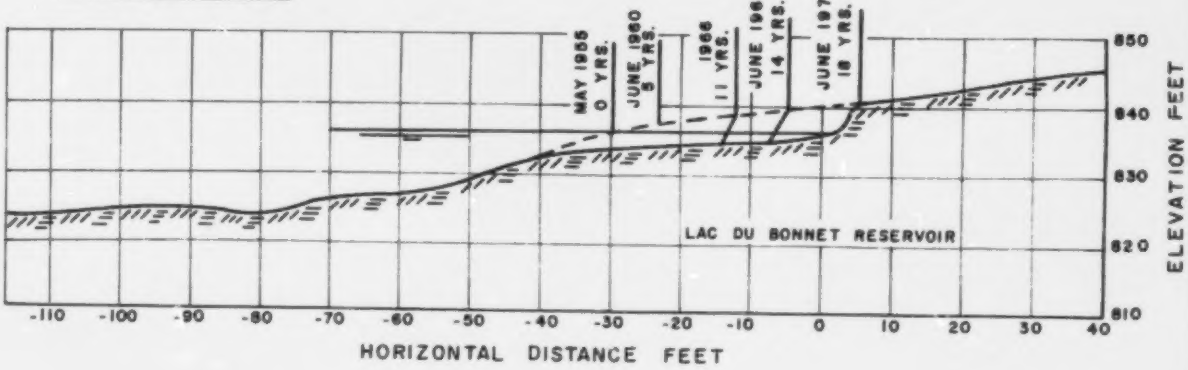
SHORELINE INVESTIGATION

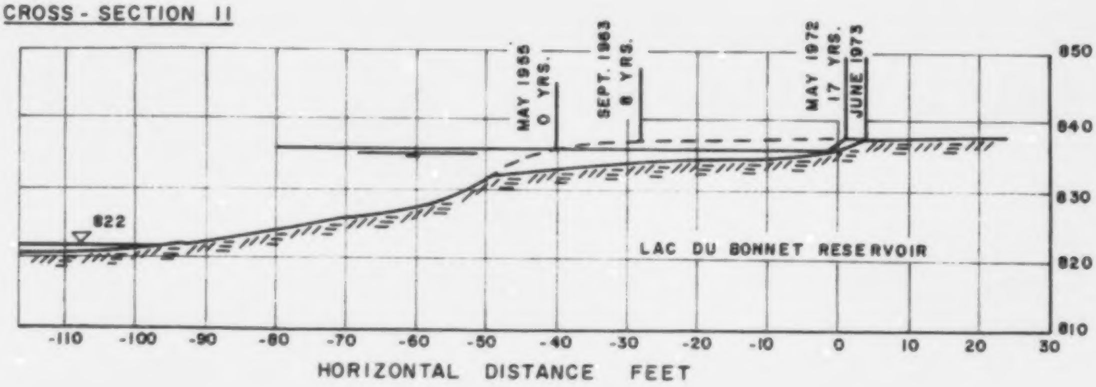
FIG. 4c - EROSION SHELVES ON BANK CROSS-SECTIONS

SCALE	DATE	SHEET	FILE NO.
SHOWN	SEP./73	6 OF 9	21-1-1177

CROSS - SECTION 10



CROSS - SECTION 11



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SHORELINE INVESTIGATION

FIG. 4d - EROSION SHELVES ON BANK CROSS-SECTIONS

PREPARED	DRAWN CHECKED	SUBMITTED DATE	APPROVED DATE	SCALE SHOWN	DATE SEP./73	SHEET 7 OF 9	FILE NO. 21-1-1177

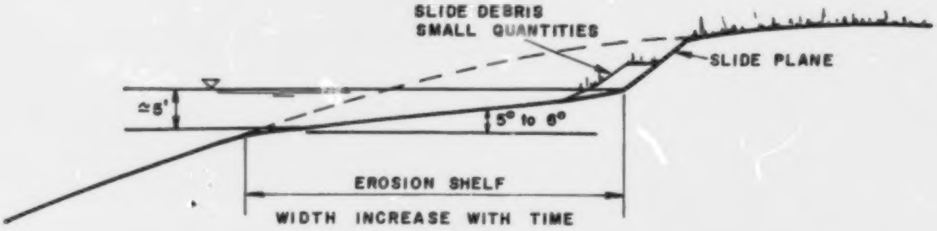
SLIDE DEBRIS
SMALL QUANTITIES
SLIDE PLANE
≃5'
5° to 6°
EROSION SHELF
WIDTH INCREASE WITH TIME

FIG. 5a - DEVELOPMENT OF EROSION SHELF WHERE HEIGHT OF BANK ABOVE WATER IS SMALL.

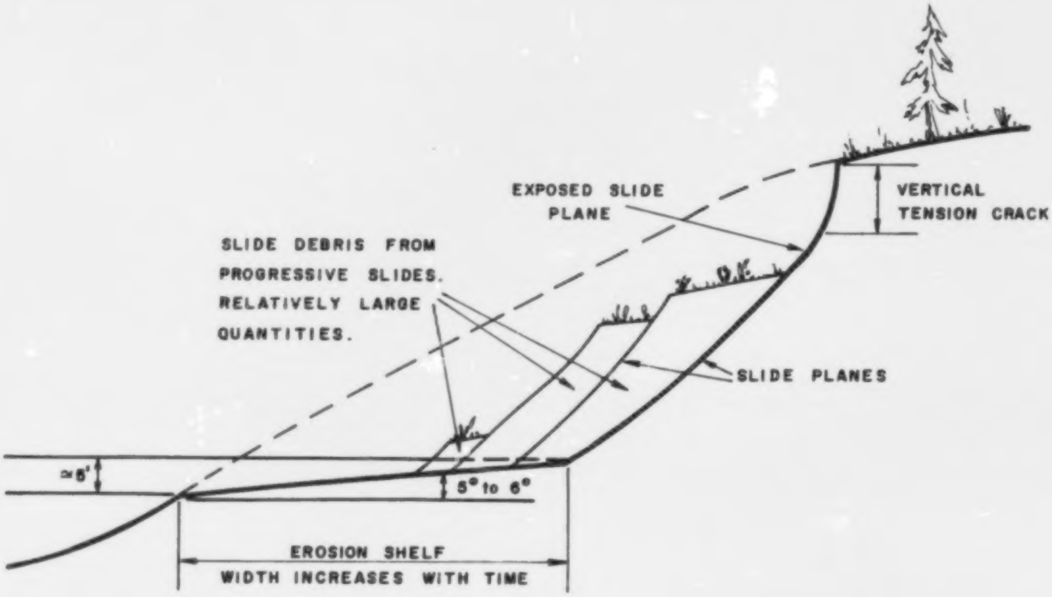
EXPOSED SLIDE
PLANE
VERTICAL
TENSION CRACK
SLIDE DEBRIS FROM
PROGRESSIVE SLIDES.
RELATIVELY LARGE
QUANTITIES.
SLIDE PLANES
≃5'
5° to 6°
EROSION SHELF
WIDTH INCREASES WITH TIME

FIG. 5b - DEVELOPMENT OF EROSION SHELF AND ACCOMPANYING SLIDING WHERE HEIGHT OF BANK IS RELATIVELY HIGH.

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WATER RESOURCES BRANCH

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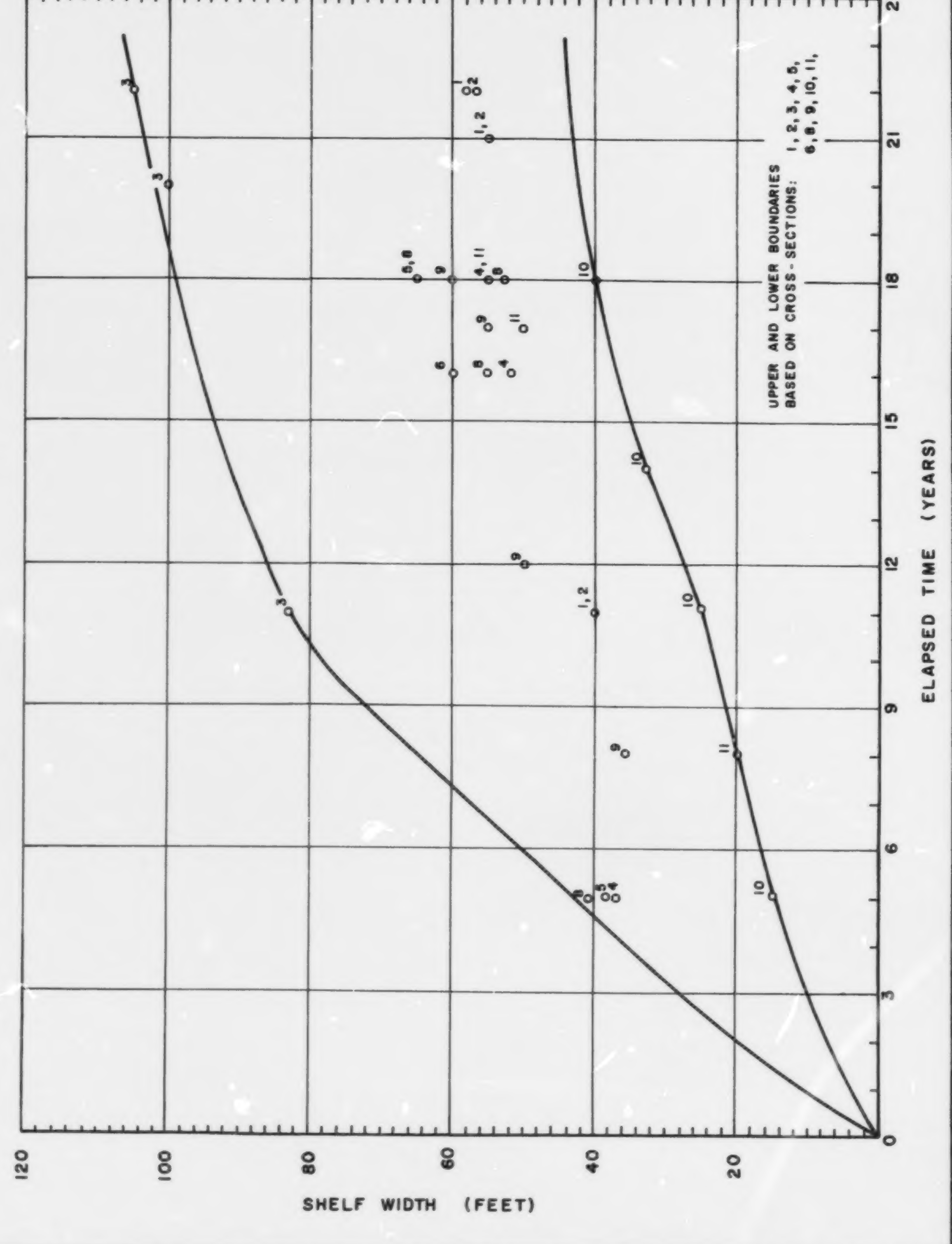
SHORELINE INVESTIGATION
FIGURES 5a and 5b

SCALE	DATE	SHEET	FILE NO.
SHOWN	SEP/73	8 OF 9	21-1-1177



PROVINCE OF MANITOBA DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT WATER RESOURCES BRANCH	CANADA - MANITOBA LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD SHORELINE INVESTIGATION FIG. 6 - GRAPH OF SHELF WIDTH VS. ELAPSED TIME FOR LAC DU BONNET EROSION

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	CHECKED	DATE	DATE

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SHOWN	SEP./75	9 OF 9	21-1-1177

APPENDIX 4 - G

PROPOSED DEVELOPMENT SET-BACK LINE FOR NELSON HOUSE, MANITOBA

PROPOSED DEVELOPMENT SET-BACK LINE
FOR NELSON HOUSE, MANITOBA

by

F. PENNER
Planning Division, Water Resources Branch
Manitoba Department of Mines, Resources and Environmental Management
Winnipeg, Manitoba
February, 1974

for

THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SPECIAL NOTE

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Note: Figures 5a and 5b are larger scale and more detailed plans of the area covered by figures 4a and 4b. Because of their sizes, they are not included in all copies of this report. They are available from the Water Resources Branch as Drawings 57-1-1005 sheet 6 of 7 and 7 of 7.

INTRODUCTION

The proposed diversion of approximately 30,000 c.f.s. from the Churchill River to the Nelson River via Rat and Burntwood Rivers will raise the level of Footprint Lake at Nelson House by approximately 20 feet. (See Figure 1.). A report on the anticipated shoreline effects of raised lake levels at Nelson House has been prepared.[1.] The report defines the limits of the flooding to be anticipated and presents estimates of the shoreline erosion to be expected at a number of points along the shoreline. At a meeting of participants in the Lake Winnipeg, Churchill-Nelson Rivers Study held at Gimli on November 29 and 30, 1973, a need was expressed for a plan showing the limits of the land to be affected by flooding or erosion. It is the purpose of this report to present such a plan together with the basis for the preparation of the plan and the interpretation to be placed on the plan.

[1.] Baracos A. and Galay V., "Anticipated Shoreline Effects of Raised Lake Levels at Nelson House, Manitoba", Lake Winnipeg, Churchill and Nelson Rivers Study, August 1973.

CONCEPT OF A DEVELOPMENT SET-BACK LINE

The parctical implications of the total impact of raised lake levels may be expressed conveniently by a "development set-back line". This is a line on a plan which indicates the limits to which land is likely to be affected by the effects of raised lake levels, and beyond which developments such as housing may safely take place. The location of the development set-back line is based on a consideration of flooding, erosion and bank stability.

It is to be noted that shoreline recession due to erosion of a clay or sand bank and the associated collapse of oversteepened banks is a continuing process, the extent of the erosion being roughly proportional to the time period over which it is measured or estimated. Hence the "development set-back line" where determined by considerations of erosion and bank stability is best interpreted as the limit to which land will be affected at the end of some "design life" normally taken to be about 50 years. The set-back line where determined by flooding, of course, is applicable immediately.

Since erosion may be controlled by the construction of certain protective works, the "development set-back line" where determined by erosion must also be based on the assumption that protective works will or will not be constructed. This report is based on the assumption that no protective works will be constructed.

RELATED STUDIES

This report is based on information and concepts contained in the following reports:

Penner F., "South Indian Lake Village, Zoning Set-Back Line Along Shoreline, Geotechnical Report", Water Resources Branch, April 25, 1973.

Baracos A. and Galay V., "Shoreline Erosion at Lac Du Bonnet and Pine Falls Reservoirs, Winnipeg River, Manitoba, " August 1973. Information appendix included in "Anticipated Shoreline Effects of Raised Lake Levels at Nelson House, Manitoba", Lake Winnipeg, Churchill and Nelson Rivers Study, September, 1973.

Baracos A. and Galay V., "Anticipated Shoreline Effects of Raised Lake Levels at Nelson House, Manitoba", Lake Winnipeg, Churchill and Nelson Rivers Study, August, 1973.

Baracos A. and Galay V., "Anticipated Shoreline Effects of Raised Lake Levels at South Indian Lake, Manitoba", Lake Winnipeg, Churchill and Nelson Rivers Study, December, 1973.

Baracos A., "Proposed Development Set-Back Line South Indian Lake Settlement", Water Resources Branch, November, 1973.

Water level information is taken from "Manitoba Hydro Report on Water and Ice Elevations in the Rat-Burntwood River System, December, 1973".

PROJECTED LAKE LEVELS AT NELSON HOUSE

The proposed development set-back line at Nelson House is based on the following lake levels:

1. The level of Footprint Lake at Nelson House is taken to be equal to the level of Threepoint Lake on the Burntwood River since the two lakes are joined by a short channel. It is assumed that no attempt will be made to isolate Footprint Lake from the Burntwood River. (See Figure 2.)
2. The natural level of Threepoint Lake (and of Footprint Lake) based on a mean natural flow of 5,000 c.f.s. is 784.
3. The projected elevations of Threepoint Lake are based on a maximum weekly mean diversion flow of 30,000 c.f.s. at Notigi plus a 5,000 c.f.s. allowance for natural flow in the Burntwood and/or short term flows higher than the weekly mean.
4. A flow of 35,000 c.f.s. under open water conditions corresponds to an elevation of 799 at Nelson House.
5. A flow of 35,000 c.f.s. under open water conditions with a power dam at Wuskwatim having a forebay elevation of 800 corresponds to an elevation of 804 at Nelson House.
6. A normal winter ice cover on the Burntwood River with a discharge of 33,200 c.f.s. will raise the level of Footprint Lake to elevation 812 in the absence of ice jams.
7. An ice jam at Wuskwatim Rapids could raise Footprint Lake to about elevation 819 with a discharge of 33,200 c.f.s. However, Manitoba Hydro has stated that Footprint Lake would not be permitted to rise above elevation 810. This could be done for example by reducing the flow at the Notigi structure or by isolating Footprint Lake from Threepoint Lake.

8. The Manitoba Hydro water levels are based on geodetic datum. Hence elevations quoted in this report are based on the same datum. Some of the contour mapping at Nelson House may be based on a slightly different datum - discrepancies of 1 to 3 feet have been mentioned. However, such errors are not critical in establishing the set-back line.

SET-BACK LINE AS CONTROLLED BY FLOODING

It is assumed that the maximum water level which will occur will be elevation 810 and that this will be under conditions of some ice cover. That is, wave runup and wind setup need not be added to this elevation. The maximum open water level of 804 plus wave runup and wind setup will not exceed 810.

It is recommended that roads or causeways in areas where the ground elevation is less than 814 have a top elevation of not less than 814 or 4 feet above the maximum probable water level in order to prevent saturation of and damage to the road bed.

It is recommended that new houses be located above the 820 contour or 10 feet above the maximum probable water level in order to prevent water problems in basements, septic fields and pipeline trenches. Application of the erosion criteria may require that new houses be set back further than the 820 contour. Existing houses below elevation 815 should be relocated or abandoned. Existing houses between elevation 815 and 820 could be relocated or abandoned if or when erosion makes this necessary during the lifetime of the buildings.

SET-BACK AS CONTROLLED BY EROSION

The erosion criteria are based on the following assumptions:

1. The banks consist of erodible clay soil similar to that at Lac du Bonnet. The report prepared by A. Baracos and V. Galay indicates this to be generally true.
2. No erosion protection measures will be applied.
3. Wave action will erode a shelf beginning 5 feet below a low water elevation of 799, then rising at a slope of 14:1 (horizontal to vertical) to 3 feet above a high water elevation of 804. Above elevation 807 a 4:1 (horizontal to vertical) backslope will develop up to the natural ground level.
4. An additional horizontal set-back of 100 feet beyond the top of the 4:1 slope is proposed to provide added safety and public access to the shoreline.

These assumptions are similar to those applied at the South Indian Lake Village. The criteria are applied to a typical slope on Figure 3.

Available information indicates that the shoreline may erode initially at a rate of roughly 1 to 5 feet per year (measured at the elevation of the water surface) and may decrease somewhat over a period of several decades. The rate of erosion depends mainly on the type of soil forming the bank, the offshore underwater slope opposite the bank, and on the width of the open water body opposite the bank. The erosion set-back as defined earlier provides an erosion allowance of about 100 feet as measured at the higher water elevation of 804. This allowance would be expended over periods of 20 to 100 years at rates of erosion of 5 to 1 feet per year respectively. The supplementary set-back distance of 100 feet at the top of the bank is intended to provide public access to the water's edge and to provide some additional protection. It is anticipated that the total set-back as defined will be adequate for a design life of 50 years under the worst conditions.

It is not considered necessary to relocate immediately buildings falling between the set-back line and the lake providing that the ground level at such buildings is above elevation 815. Such buildings can be relocated or abandoned if or when erosion makes this necessary during the lifetime of the existing buildings.

APPLICATION OF DEVELOPMENT SET-BACK LINE CRITERIA

The preceeding criteria were applied uniformly over the entire settlement although it was recognized that the severity of shoreline erosion as determined by offshore water depth and width of lake would vary along the shoreline. It was found generally that in sheltered areas where the erosion would be less than estimated, the flooding criteria governed and that in exposed areas, where the erosion estimate would be realistc, the erosion criteria governed.

The set-back line as shown on the plans is intended to illustrate the practical implications of the raised lake levels. Minor variations in location of the line could be made because of field conditions.

The set-back line developed on this basis is shown on Figures 4a and 4b at a scale of 1" = 800' and on Figures 5a and 5b at a scale of 1" = 400'.

LIMITATIONS OF THIS STUDY

The assumptions and the limitations of the data on which this study is based need to be emphasized.

The set-back line where determined by erosion is intended to indicate a condition which might be achieved over a period of roughly 50 years. Probably most of the houses now located between the shoreline and the set-back line will naturally become obsolete before they will be affected by erosion. However, it would be prudent to locate new developments above the set-back line.

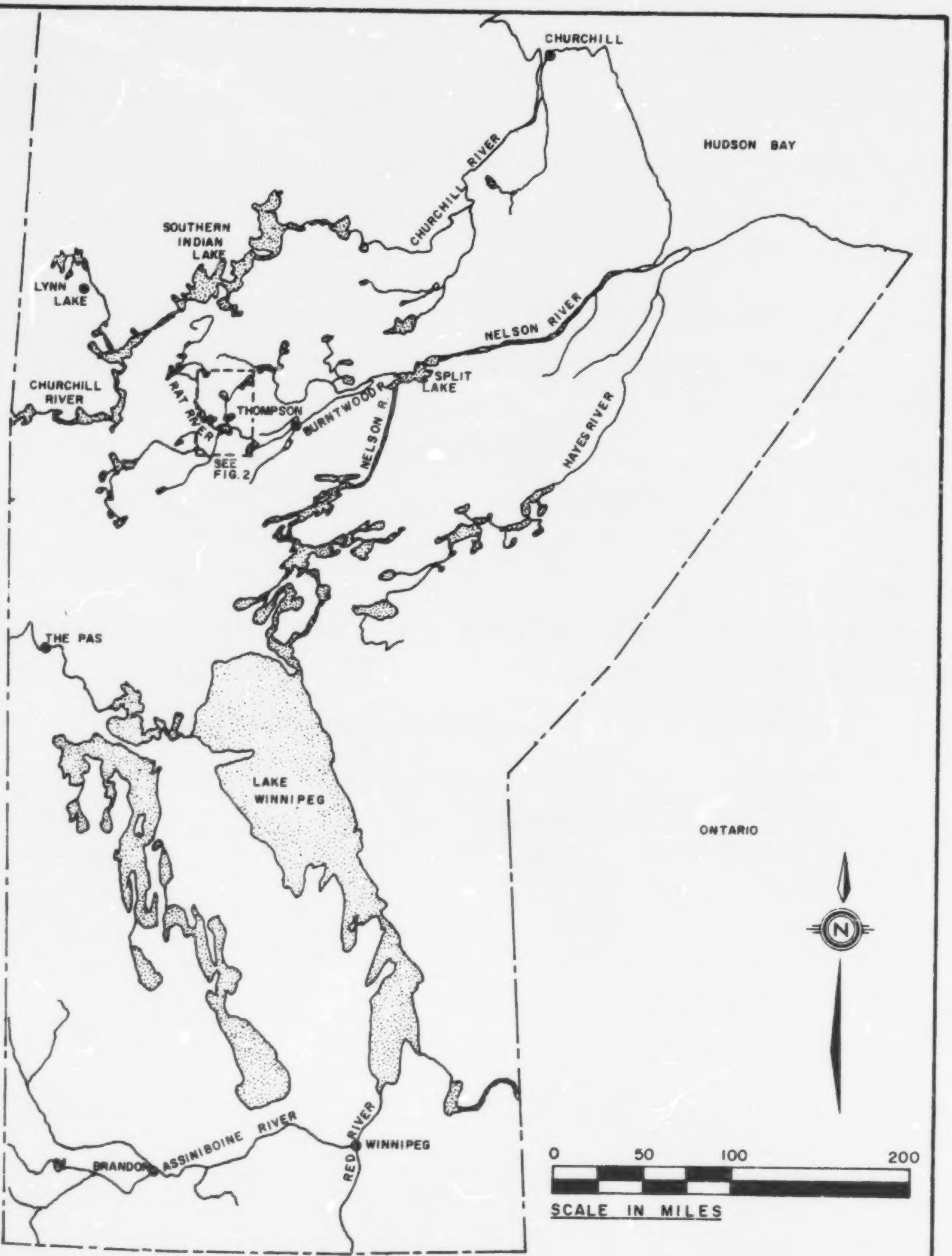
The study assumes that all banks consist of erodible soil over the range of elevations affected by erosion. There is some evidence that the bedrock under the clay bank in the vicinity of cross-sections 16 and 17 on Figure 4A rises to the proposed raised lake level and that the shoreline recession in this area would be arrested when the bedrock surface is reached. In this case the development set-back line would be moved closer to the shoreline.

The study also assumes that no erosion protection works would be constructed. The point of land between cross-sections 18 and 19 on Figure 4A which includes a cemetery might be protected by placing rock rip-rap along the shoreline.

NEED FOR FURTHER INVESTIGATIONS

At this time it appears that several additional investigations are warranted:

1. Determine whether erosion along the shoreline between cross-sections 15 and 20 would be limited by bedrock rising to an elevation of about 804 under the existing clay bank. This would require drilling approximately 30 auger holes.
2. Determine whether the point of land between cross-sections 18 and 19 on Figure 4A should be protected or be abandoned. The cemetery is likely the critical factor here.
3. Prepare a land use plan indicating areas of future developments so that need for and location of raised roadways, docks and timber clearing along the shoreline can be established.


CHURCHILL
HUDSON BAY
CHURCHILL RIVER
SOUTHERN INDIAN LAKE
LYNN LAKE
NELSON RIVER
SPLIT LAKE
CHURCHILL RIVER
RAT RIVER
THOMPSON
BURNTWOOD R.
NELSON R.
SEE FIG. 2
HAYES RIVER
THE PAS
LAKE WINNIPEG
ONTARIO
N
ASSINIBOINE RIVER
RED RIVER
WINNIPEG
BRANDON
0
50
100
200
SCALE IN MILES

PROVINCE OF MANITOBA
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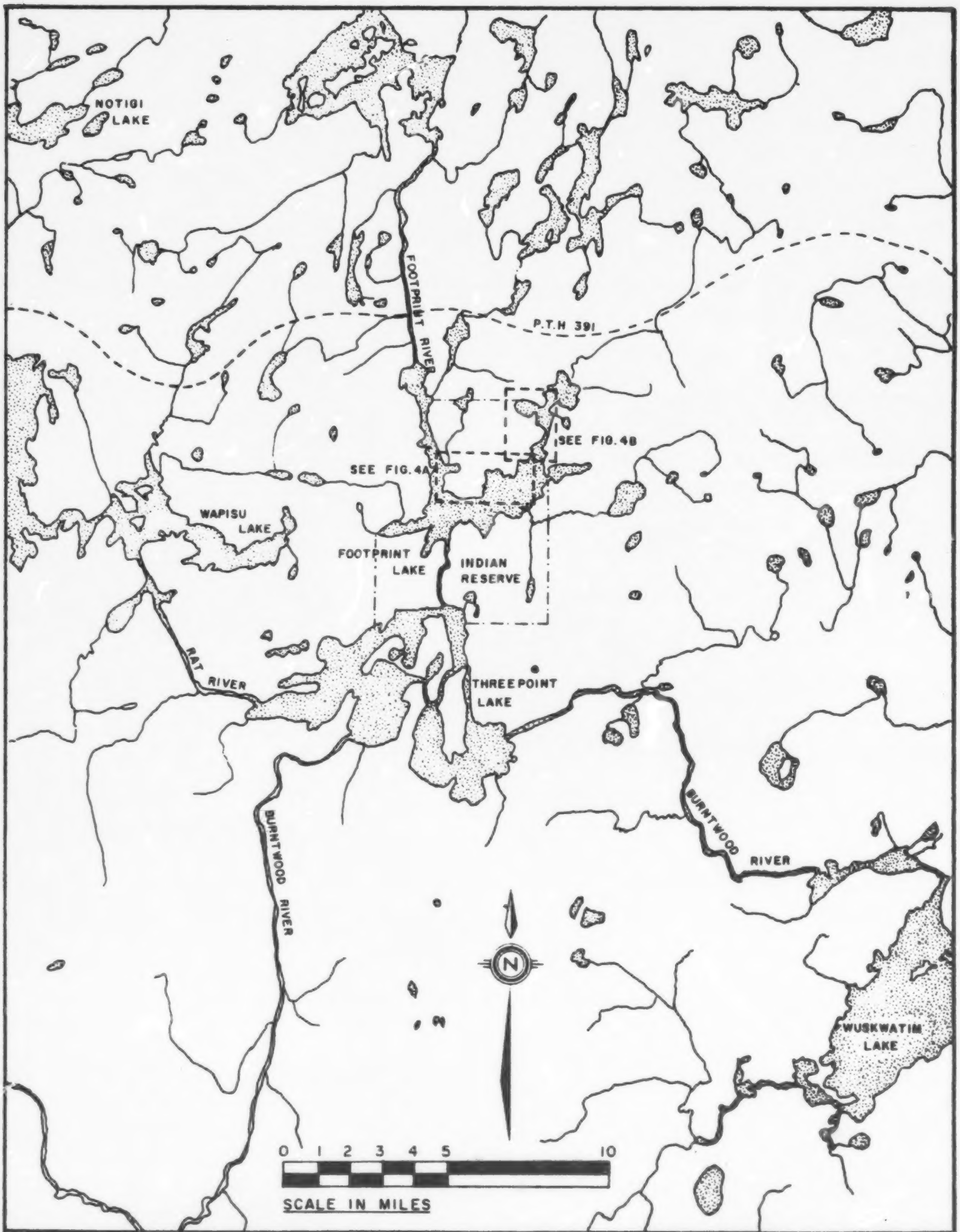
CANADA - MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

NELSON HOUSE SETTLEMENT
PROPOSED DEVELOPMENT SET BACK LINE
LOCATION PLAN

FIG. 1

PREPARED	DRAWN	SUBMITTED F.P.	APPROVED	SCALE AS SHOWN	DATE JAN.74.	SHEET 1 OF 7	FILE No 57-1-1005
	CHECKED	DATE 14 FEB 1974	DATE				


NOTIGI LAKE
FOOTPRINT RIVER
P.T.H. 391
SEE FIG. 4B
SEE FIG. 4A
WAPISU LAKE
FOOTPRINT LAKE
INDIAN RESERVE
RAT RIVER
THREEPOINT LAKE
BURNTWOOD RIVER
BURNTWOOD RIVER
WUSKWATIM LAKE
N
0 1 2 3 4 5 10
SCALE IN MILES

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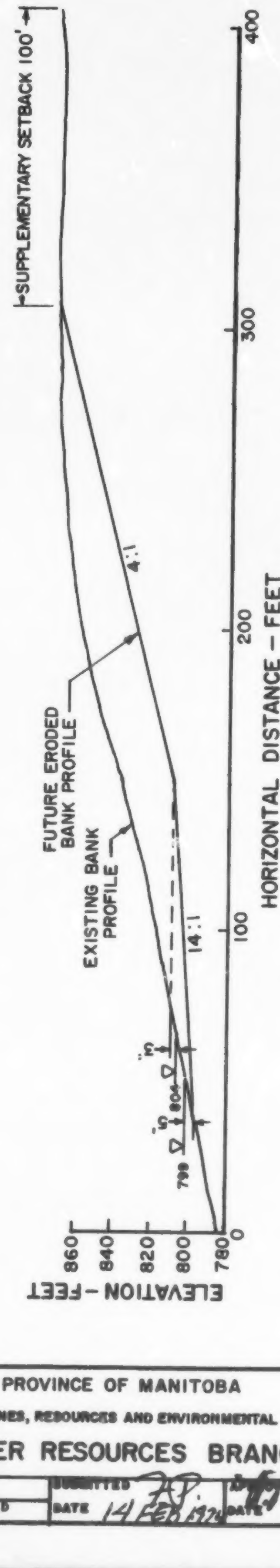
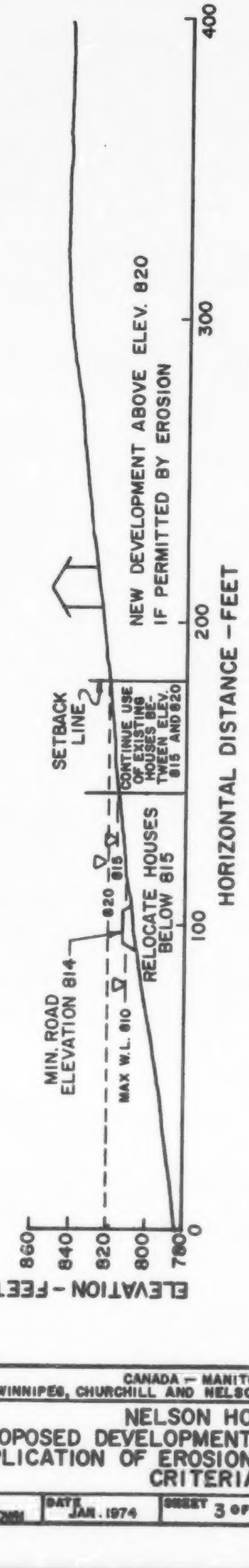
NELSON HOUSE SETTLEMENT
PROPOSED DEVELOPMENT SET BACK LINE
KEY PLAN

FIG. 2

SCALE	DATE	SHEET	FILE NO.
AS SHOWN	JAN. 74.	2 OF 7	57-1-1005


SUPPLEMENTARY SETBACK 100'
FUTURE ERODED BANK PROFILE
EXISTING BANK PROFILE
4:1
14:1
799
804
5'
3'
ELEVATION - FEET
860
840
820
800
780
0
100
200
300
400
HORIZONTAL DISTANCE - FEET

APPLICATION OF EROSION CRITERIA


MIN. ROAD ELEVATION 814
MAX W.L. 810
820
815
RELOCATE HOUSES BELOW 815
SETBACK LINE
CONTINUE USE OF EXISTING HOUSES BETWEEN ELEV. 815 AND 820
NEW DEVELOPMENT ABOVE ELEV. 820 IF PERMITTED BY EROSION
ELEVATION - FEET
860
840
820
800
780
0
100
200
300
400
HORIZONTAL DISTANCE - FEET

APPLICATION OF FLOODING CRITERIA

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NELSON HOUSE
PROPOSED DEVELOPMENT SETBACK LINE
APPLICATION OF EROSION AND FLOODING CRITERIA

SCALE	DATE	SHEET	FILE NO.
AS SHOWN	JAN. 1974	3 OF 7	57-1-1005

FIG. 3

APPENDIX 4 - H

ANTICIPATED EFFECTS OF RAISED LAKE LEVELS ON SHORELINES AT SOUTH INDIAN LAKE, MANITOBA

ANTICIPATED EFFECTS OF RAISED LAKE LEVELS ON SHORELINES AT SOUTH INDIAN LAKE, MANITOBA

by

A. BARACOS and V. GALAY
Department of Civil Engineering
University of Manitoba
Winnipeg, Manitoba
December, 1973

sub-contracted by:

Water Resources Branch
Manitoba Department of Mines, Resources and Environmental Management
Winnipeg, Manitoba

for

THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

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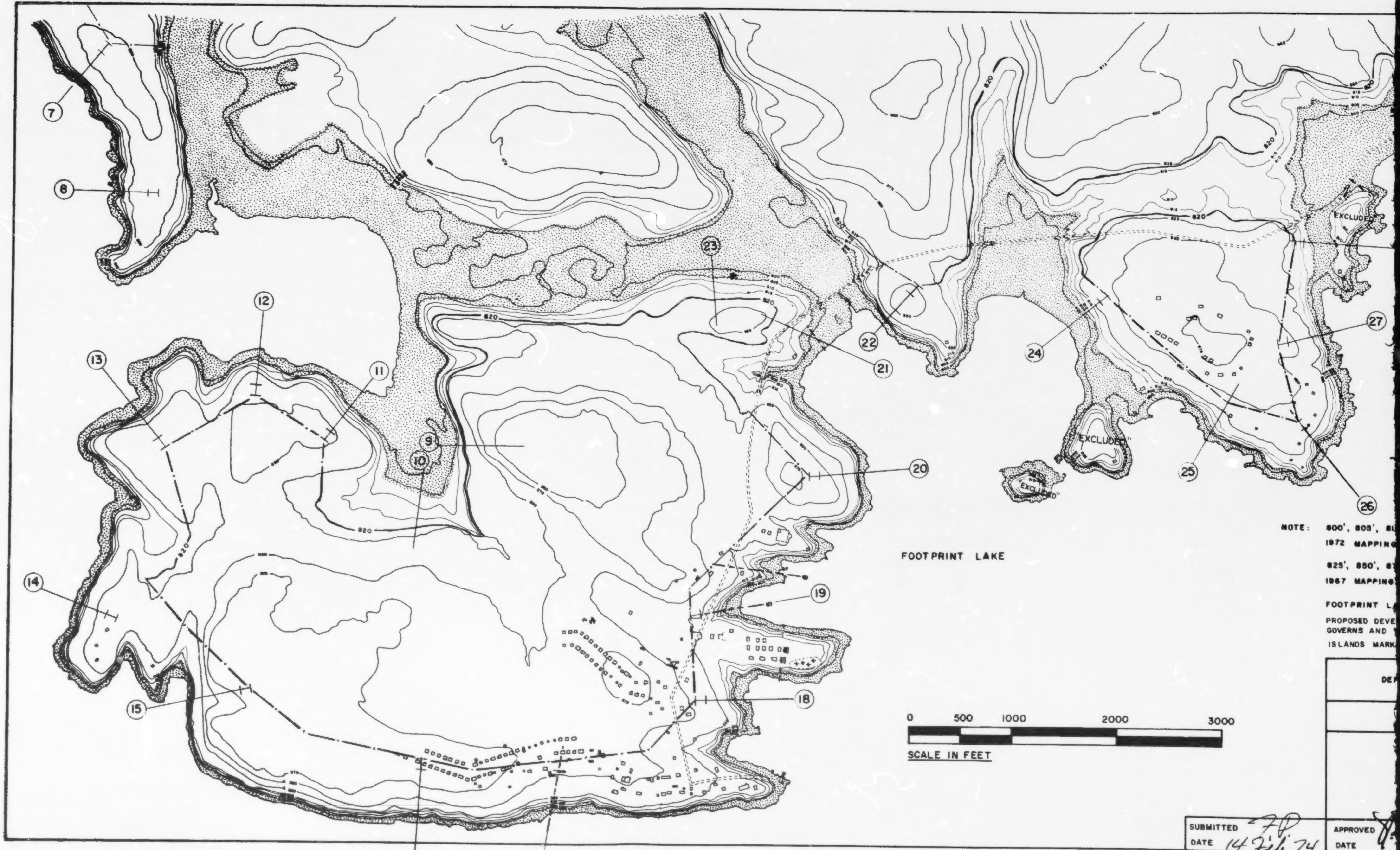

7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
"EXCLUDED"
"EXCLUDED"
"EXCLUDED"
820
850
875
FOOTPRINT LAKE
0
500
1000
2000
3000
SCALE IN FEET

NOTE: 800', 805', 8
1972 MAPPING

825', 850', 8
1967 MAPPING

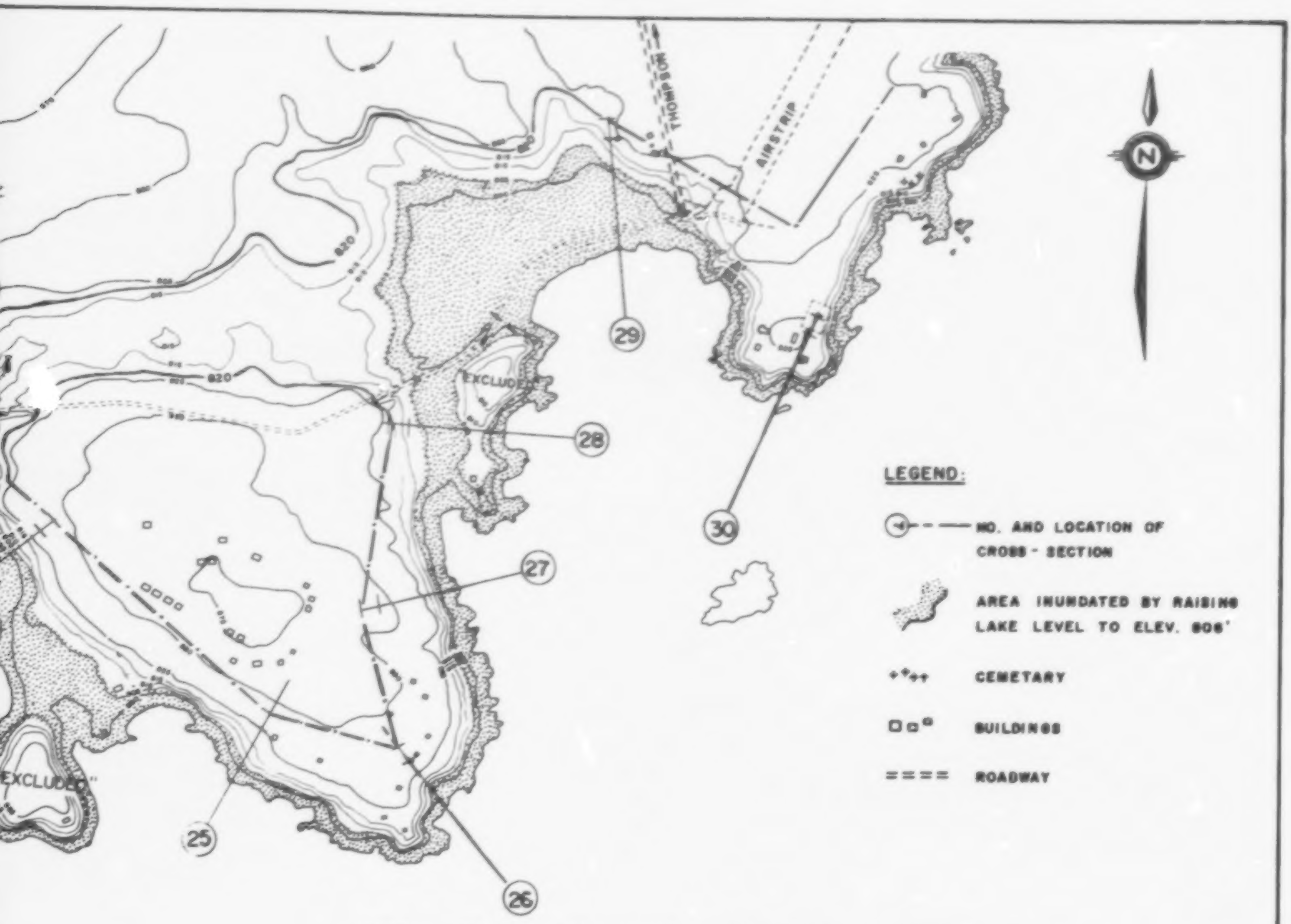
FOOTPRINT L

PROPOSED DEVE
GOVERNS AND

ISLANDS MARK

DE

SUBMITTED FP	APPROVED
DATE 14 Feb 74	DATE


THOMPSON
AIRSTRIP
N
820
EXCLUDED
EXCLUDED"
25
26
27
28
29
30
LEGEND:
NO. AND LOCATION OF CROSS - SECTION
AREA INUNDATED BY RAISING LAKE LEVEL TO ELEV. 806'
CEMETARY
BUILDINGS
ROADWAY
2000
3000

NOTE: 800', 805', 810' AND 815' CONTOURS BASED ON LOCKWOOD SURVEY 1972 MAPPING.

825', 850', 875' AND 900' CONTOURS BASED ON WESTERN PHOTOGRAMMETRY 1967 MAPPING.

FOOTPRINT LAKE ELEVATION JULY 1973 783.6'

PROPOSED DEVELOPMENT SET BACK LINE IS ELEV. 820 CONTOUR WHERE FLOODING GOVERNS AND DOT DASH—·— LINE WHERE EROSION GOVERNS.

ISLANDS MARKED "EXCLUDED" ARE UNSUITABLE FOR DEVELOPMENT.

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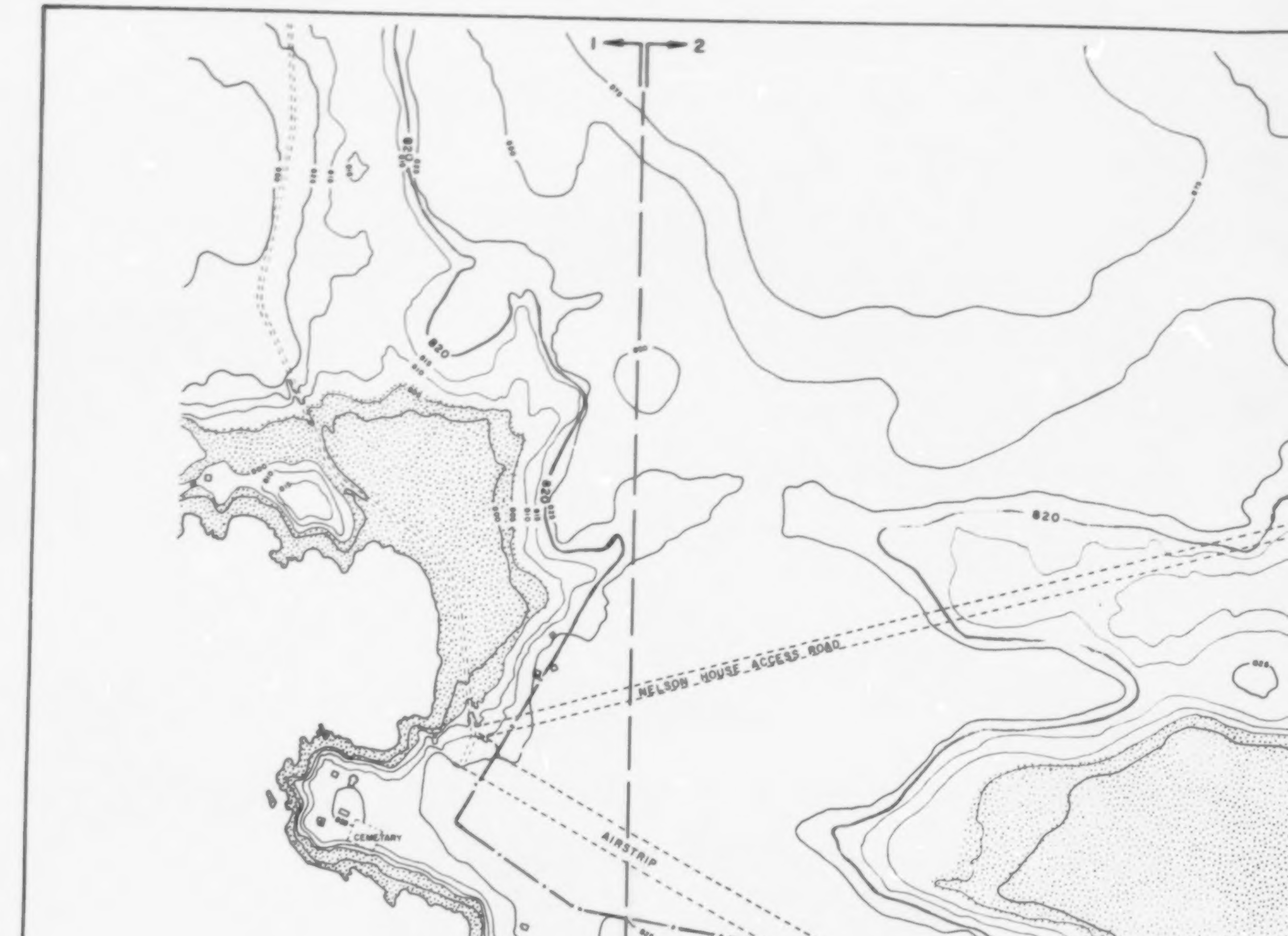
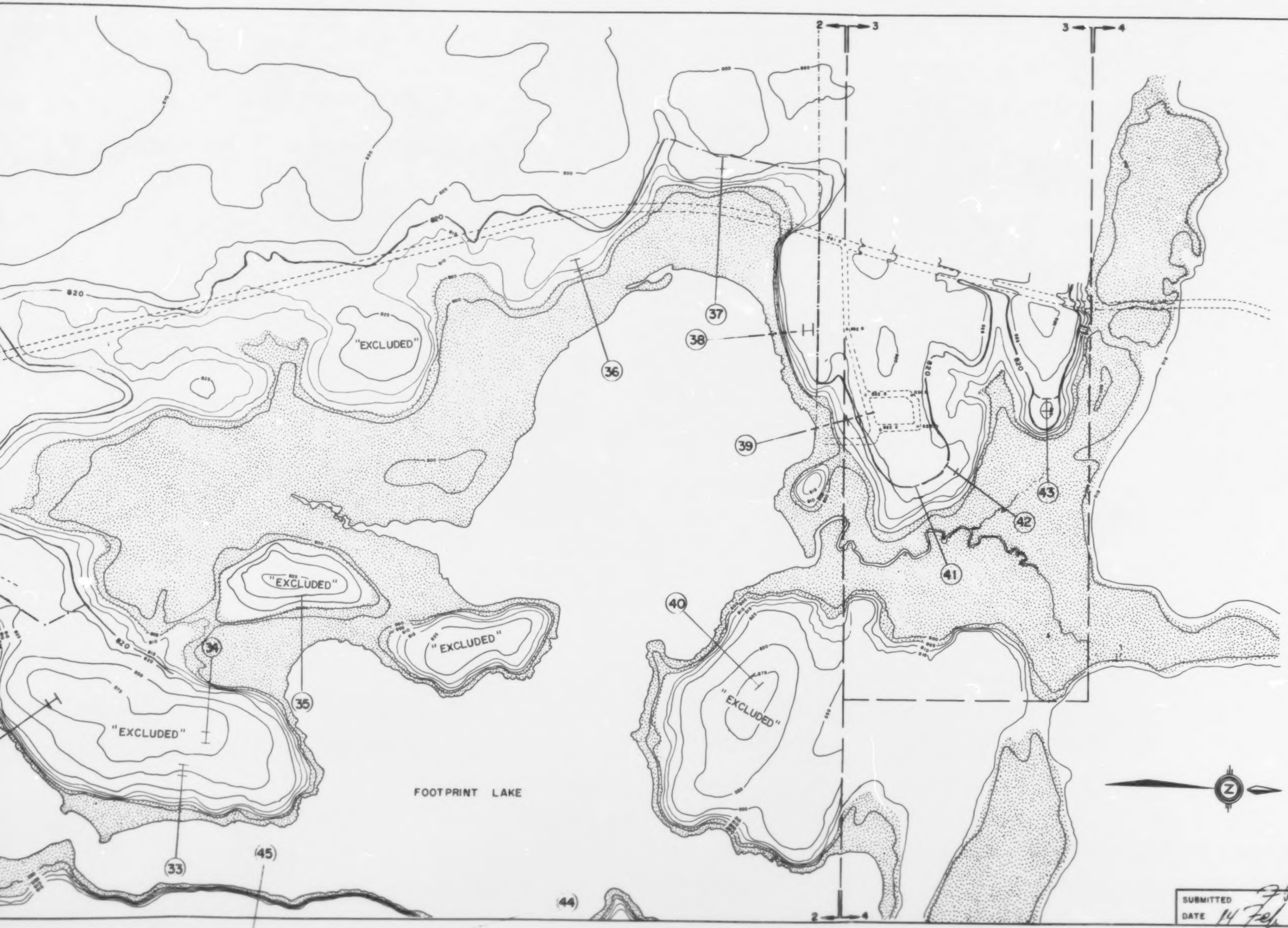
NELSON HOUSE SETTLEMENT
PROPOSED DEVELOPMENT SETBACK LINE
CONTOUR PLAN (SOUTH HALF)

FIG. 4-A

SUBMITTED DATE 14 Feb 74	APPROVED DATE	DATE JAN. 1974	SHEET NO. 4 OF 7	FILE NO. 57-1-1005


1
2
820
NELSON HOUSE ACCESS ROAD
AIRSTRIP
CEMETARY
820
810
800
31
2
32
"EXCLUDED"
34
CEMETARY
33


2 → 3
3 → 4
2 → 4
820
810
800
"EXCLUDED"
"EXCLUDED"
"EXCLUDED"
"EXCLUDED"
"EXCLUDED"
33
34
35
36
37
38
39
40
41
42
43
(44)
(45)
FOOTPRINT LAKE
Z

LEGEND:

(31)- - — NO. AND LOCATION OF CROSS SECTION

▨ AREA INUNDATED BY RAISING LAKE LEVEL TO ELEV. 806'

✝✝✝✝ CEMETARY

□□□ BUILDINGS

==== ROADWAY

NOTE:

CONTOURS IN SECTION 1-1 BASED ON FIGURE 4A

CONTOURS IN SECTION 2-2 BASED ON WESTERN P
1967 MAPPING

CONTOURS IN SECTION 3-3 BASED ON LOCKWOOD
1972 MAPPING

CONTOURS IN SECTION 4-4 BASED ON BURNTWOOD
MAPPING PROJECT 1972

FOOTPRINT LAKE ELEVATION JULY 1973 783.5'

PROPOSED DEVELOPMENT SET BACK LINE IS ELEV. 820 C
GOVERNS AND DOT DASH —·— LINE WHERE EROSION

ISLANDS MARKED "EXCLUDED" ARE UNSUITABLE FOR D

0 500 1000 2000

SCALE IN FEET

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LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS

NELSON HOUSE SETTLEME
PROPOSED DEVELOPMENT SET BA
CONTOUR PLAN (NORTH HAL

SUBMITTED FP DATE 14 Feb 74	APPROVED Mundy DATE	DATE JAN. 1974	SHEET NO. 5 OF 7	FILE

LEGEND

(31)- - - NO. AND LOCATION OF CROSS SECTION

AREA INUNDATED BY RAISING LAKE LEVEL TO ELEV. 806'

† † † † CEMETARY

☐▫▫ BUILDINGS

= = = = ROADWAY

NOTE:

CONTOURS IN SECTION 1-1 BASED ON FIGURE 4A

CONTOURS IN SECTION 2-2 BASED ON WESTERN PHOTOGRAMMETRY 1967 MAPPING

CONTOURS IN SECTION 3-3 BASED ON LOCKWOOD SURVEY 1972 MAPPING

CONTOURS IN SECTION 4-4 BASED ON BURNTWOOD RIVER MAPPING PROJECT 1972

FOOTPRINT LAKE ELEVATION JULY 1973 783.5'

PROPOSED DEVELOPMENT SET BACK LINE IS ELEV. 820 CONTOUR WHERE FLOODING GOVERNS AND DOT DASH —·— LINE WHERE EROSION GOVERNS.

ISLANDS MARKED "EXCLUDED" ARE UNSUITABLE FOR DEVELOPMENT.

0 500 1000 2000 3000

SCALE IN FEET

PROVINCE OF MANITOBA
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NELSON HOUSE SETTLEMENT
PROPOSED DEVELOPMENT SET BACK LINE
CONTOUR PLAN (NORTH HALF)

FIG. 4-B

SUBMITTED F.P. DATE 14 Feb. 74	APPROVED J. Mudry DATE	DATE JAN. 1974	SHEET NO. 5 OF 7	FILE NO. 57-1-1005

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6	Abandoned church on east shoreline.
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7A	Area Inundated by Raising Lake Level to Elevation 850 Location of Cross-Section Lines, Proposed Development Set-Back Line.

ABSTRACT

This report deals with the effects on the shoreline at South Indian Lake Settlement resulting from raising Southern Indian Lake by 10 feet, and possibly in the future to 13 feet, above the present level. During the summer of 1973, studies were undertaken of shoreline, soil and other conditions in relation to proposed raised water levels. The studies show that a major extent of the banks are controlled by bedrock and will not be subject to significant erosion or sliding. This is not the case, however, in the vicinity of the proposed community center and some other habitated areas. However, it is possible to establish on the basis of comparable experience elsewhere, an estimate of how much erosion and sliding could take place in a foreseeable time, say 50 years, if no protection measures are taken. This approach has been taken in establishing criteria for a set-back line so that the planned development of the settlement will not be adversely affected by high water. The criteria for the set-back line are examined in this report.

It is also noted that it is possible to protect banks from erosion, and this course of action can be taken to protect the cemetery which is located on a highly erodible bank. There are possibly other areas which may be similarly desirable to protect. Experience at Lac du Bonnet and Pine Falls indicate that rip-rap can very effectively be used to control erosion. It has also been shown that man-made beaches can be constructed at higher levels to replace those inundated.

The settlement of South Indian Lake has until very recently been an isolated, wilderness community. The raising of the lake will not destroy such facilities as pumping stations, sewage treatment works, power lines, etc. which have been virtually non-existent. These facilities will be made available in

the proposed development including the community center, for which planning has fully anticipated the effects of the raised lake levels. Raised lake levels have also been taken into account in locating new homes to replace older homes, mostly cabins, some of which have already been abandoned.

Attention is drawn to the need for engineering advice on the location of new homes and other buildings not only for reasons related to new water levels, but for very important but unrelated reasons. For example, wood blocks supported on ground surface have been used for foundations for new homes. These will undergo damaging differential settlements even under ideal conditions with no permafrost. Some of the sites undoubtedly have permafrost which will thaw and cause severe settlement. Although not within the terms of reference, the writers wish to point out the need for technically trained local people to service the communities very changed needs. Such training has already started with regard to house-building.

TERMS OF REFERENCE

The Manitoba Hydro diversion of water from the Churchill into the Nelson River System by way of the Rat and Burntwood Rivers requires the raising of Southern Indian Lake. The lake will be raised from its present elevation of about 837, to elevation 847, and possibly in the future to elevation 850. This report deals with the effects of the raised water level on the shoreline in the vicinity of South Indian Lake Settlement and is based on the study of available topographic plans, aerial photographs, and field investigations undertaken during July and August, 1973.

A concurrent study undertaken by Manitoba Hydro, also required field information on topographic and soil conditions at South Indian Lake. To avoid unnecessary duplication of effort, and to make possible the obtaining of a maximum of data in the short summer season, the field efforts of both the Manitoba Hydro and Water Resources Branch were co-ordinated. It was agreed to share all un-interpreted data.

Data obtained by the Water Resources Branch during a preliminary study in the early part of 1973, and reported by Penner(1) was also examined. Reference is made to a study of shoreline erosion at Lac du Bonnet and Pine Falls reservoirs in southern Manitoba involving soils of comparable geological origin. The results of this latter study are given in a separate appendix report by Baracos and Galay.(2)

Bank profile elevations have been referenced to lake level which in turn has been referenced to a benchmark, elevation 839.58 consisting of a brass cap in rock, located about 20 feet west and 3 feet north of the M.G.A.S. dock at South Indian Village.

SCOPE OF STUDY

Figures 1 and 2 locate the study area. Preliminary work included: a visual examination and classification of the existing shoreline, the taking of photographs and the selection of areas for detailed studies. Figure 3 summarizes the classification and shows the location of photographs used in the report. Also shown are average velocities for open water and under 3 feet of ice (in brackets), for lake level elevation 847, and an assumed flow of 30,000 cfs, at locations where constricted flow gives rise to higher velocities.

Existing information was compiled to provide a plan as complete as possible, showing existing main buildings, roads under development, the airstrip, etc., in relation to a raised lake elevation of 850. This information is shown in Figure 4. It must, however, be noted that new construction and abandonment or removal has already made some building location information obsolete or incomplete. Figure 4 also shows the locations of Cross-Sections 1 to 83, where topographical and soil information were obtained. Drilling employed gasoline-powered drills, light enough to be manually carried to sites otherwise inaccessible. Limits of time and resources generally precluded more than one or two holes at each site investigated. Drilling was stopped when further penetration by auger became impossible. Representative bulk soil samples were obtained and subjected to moisture content and identification tests at the Soil Mechanics Laboratory, Water Resources Branch in Winnipeg. Typical cross-sections of the banks, including test holes and summarized test results in the vicinity of the community center, are shown in Figures 5-1 to 5-3 inclusive. Similar results for the remaining cross-sections are available on file at the Water Resources Branch under File No. 61-6-1044.

Analysis of the anticipated effects of the raised water level were made on the basis of data obtained during the current study and comparison to experience elsewhere. Particular reference is made to an appendix report under separate cover by Baracos and Galay(2) dealing with erosion experience at Lac du Bonnet and Pine Falls reservoirs in southern Manitoba.

GEOTECHNICAL AND SURFICIAL FEATURES

The narrows joining South Bay to Southern Indian Lake are formed by a depression in the Precambrian bedrock. On either side of the narrows, and on a number of small islands, where the shoreline is not protected from wave action, erosion has exposed the bedrock. The wharf shown in Photograph 2, is supported on bedrock. The light colored bedrock at the water's edge shows on Photographs 3 to 6. Figure 3 shows that the exposed bedrock shoreline predominates except in the sheltered bays. However, it is largely in the bays that the lake fronts on areas presently developed, or which are proposed for development.

Bank heights are relatively low. Although, high ground rises as much as 150 to 170 feet above the present lake level, the rise close to the water's edge is generally much less; banks near the water's edge are 10 to 40 feet above present lake level. In many cases, the bedrock is covered by only a few feet of soil.

Clay was found to be the most common soil material. On the basis of tests from the initial investigation of Cross-Sections 1 to 21, the clay properties are summarized in Table 1.

Table 1 - Summary of Clay Properties

Property	Mean	Range	No. of Tests
Water Content	30	26-33	30
Liquid Limit	47	41-56	12
Plastic Limit	22	20-25	12
Plasticity Index	25	19-32	12
Unconfined Compressive Strength, p.s.f.	2600	1700-3400	8
Pocket Penetrometers, p.s.f.	2700	1200-7000	16

The liquid limit and plasticity index values classify the clays as ranging from low plasticity (CL) to intermediate plasticity (CI), with a few samples having a liquid limit of just over 50, sufficient to classify them as having high plasticity. Apart from being somewhat less plastic, the clays of South Indian Lake Settlement are similar to the glacial Lake Agassiz clays of southern Manitoba. For Cross-Sections 22 to 83, advantage was taken of the more extensive sampling and testing on the first 21 cross-sections, to limit subsequent sampling to moisture content and bulk samples suitable for identification. For soil properties at typical sites, the reader is refered to the test hole logs included in Figures 5-1 to 5-3.

Moss was found to be the principal organic cover on the soils or bedrock. The test hole showed relatively thin or negligible organic cover. Exceptions include Cross-Sections 59 and 75, where up to 8 feet of peat was encountered. It is expected that organic cover may be quite thick in a number of similar low areas where test holes were not drilled including Cross-Sections 57, 58 and 76.

Clayey silt (ML) and sandy silt (SM) were found to occur as a thin layer between the clay and underlying bedrock in some locations. More substantial thickness of silter and sandier soils occur in more or less isolated locations as those shown in Cross-Sections 79 and 81. The substantial thicknesses of sandy silt in Cross-Sections 43 and 44 probably reflect generally more sandy conditions of the east shore of the most northerly area of the narrows. From visual examinations of the soils on top of grave mounds at Cross-Section 40, it is likely that a substantial thickness of sandy silt or silty fine sand is had at this location. No test holes were drilled in the cemetery.

Permafrost conditions do not appear to be extensive along the shoreline at South Indian Lake Settlement. The unstable bank shown in Photograph 10 is an exception. Ice was visible in the eroded face of the bank.

The presence of ice adjacent to the present water's edge, can be explained on the basis that the adjacent water is shallow at Cross-Section 76 (Figure 4). Normally, permafrost would not be expected immediately adjacent to a body of water which can act as a year-round heat source. However, with a shallow depth, the water freezes to the bottom and is not a heat source of above-freezing temperatures during the winter. The area shown in Photograph 10 will be inundated by raising the lake to elevation 847 or 850, and is not proposed for development. It is presently uninhabited.

Shallow water may also be a contributing factor to permafrost being found within less than 200 feet of the water's edge at Cross-Sections 11 and 64, (Figure 4). However, even for test holes located 400 to 500 feet from the water's edge, permafrost was found no deeper than 9 to 12 feet, and in many cases was not found at all. Samples of permafrost brought into the laboratory and allowed to thaw did not differ significantly in appearance, water content or strength from samples from the zone of seasonal frost or from depths below the permafrost zone.

Ice segregation in the permafrost samples tested appears very limited. No major ice lenses were noticed by the drillers. Moisture contents were generally near the plastic limit indicating no layers where an excess moisture would result from ice lenses.

Figure 3 shows three sections of bank marked "Slumping Clay". The slumping refers primarily to relatively limited sliding of clays just above the toe of the bank. This sliding appears to be caused by wave uprush eroding a vertical face which subsequently "slumps". Generally, the banks through the narrows are stable with no visual evidence of past movement.

SOUTHERN INDIAN LAKE ELEVATIONS

Table 2 summarizes water elevation data at South Indian Lake Settlement.

Table 2 - Lake Elevations at South Indian Lake Settlement

	Natural Levels	Regulated Levels
Minimum	832	844.6
Mean	836	846.6
Maximum	841	847. (+ 3 feet)

The regulated maximum level may in the future be raised by three feet if required to assure necessary diversion flows of 30,000 cfs. For the purpose of this study, it has been assumed that wave uprush could affect an elevation 3 feet higher than the maximum level. Included in this additional figure is an allowance for ice action and possible flood surcharge. The extent of wind setup at the settlement is difficult to compute because of the configuration of the lake and the presence of many islands in the narrows. It is thought that a positive setup at one end of the narrows coupled with a negative setup at the other end will result in little change in lake levels at the settlement.

It is important however, to realize that flow velocities through the narrows under open water conditions can be higher than indicated on Figure 3. Northerly winds would result in a positive setup at the north end of the narrows which would increase flow velocities between the islands.

The flow of 30,000 cfs through the narrows would result in the development of large eddies in the bays. These areas would be the future collecting areas for floating trees. The patterns and extent of the developed eddies is difficult to predict; hydraulic model studies would be necessary to further study this phenomenon.

EFFECTS OF INUNDATION

Figure 4 shows the areas that will be inundated by raising the lake to elevation 850. The inundated area will only be slightly reduced by a raise to elevation 847.

A sparsely inhabited area near Cross-Sections 30 and 31 (Figure 4) will become an island. Flooding of the saddle traversed by Cross-Section 58 will make an island of the section of west bank on which the existing school, nursing station and store are located. The island can be jointed to the mainland by raising of the grade of the present trail crossing this saddle when it is developed into a roadway.

The area has yet to aquire a roadway system other than that provided by unimproved trails. Development of a roadway system will require raised grades in the vicinity of Cross-Sections 57 and 76. A recently constructed foot bridge crossing a creek near Cross-Section 15A will have to be raised. Three docks used by float planes and boats, and a number of smaller docks used by local boat owners will also have to be raised.

In anticipation of raised levels, work has been underway on new houses, a community center including school, store, nursing station and recreation facilities to replace facilities that are being abandoned. About a dozen older buildings, mostly cabins, will be directly affected by raised water levels. Some additional older buildings may require moving or abandonment in future from either the effects of raised water table or future shoreline erosion and possible sliding. The present nursing station and some buildings near the present school are mobile units which can be moved.

The development of the community will see electric power extended throughout. This will make available for the first time a pumped water supply and sewage treatment for the community center. Since these are new facilities, they are being planned on the basis of raised water levels.

Much of the travel in the area during summer is by boat. As can be seen from Photographs 1 to 10, the shoreline to be inundated has tree cover. The trees will require clearing to provide shoreline accessibility, and to permit the development of shorelines comparable to those currently existing. Winter travel across the ice will involve possible risk. Experience for example on the St. Lawrence River has shown that ice will form with velocities under 1.3 to 1.4 feet per second. Once formed ice will remain with velocities up to about 2.5 ft. per sec. It is not possible to extrapolate St. Lawrence River conditions to northern Manitoba where the cold is more extense. However, it must be noted that the average velocities at the constricted narrow section (see Figure 3), considerably exceed 1.3 to 1.4 ft. per sec., and that localized velocities higher than average can be expected. Localized areas of open water or weak ice conditions should thus be anticipated. It may be necessary to consider raft or similar temporary bridges for winter use.

The raised water level will cause effects related to elevation and shoreline erosion. These considerations have made it necessary to establish a set-back line so that the planned development of South Indian Lake Settlement will not be adversely affected. In the subsequent sections of this report, the factors to be considered in establishing a proposed set-back line are considered. The actual set-back line will be established by Manitoba Hydro. Future building will have to be constructed beyond the set-back line, but existing building, etc. closer to the lake, but not flooded may remain until such time as erosion, sliding or other effect endangers their safety. In some cases this may mean up to 10 to 20 years or more of useful life for structures but no guarantees can be given.

FUTURE EROSION AND STABILITY OF SHORELINE

In terms of erosion effects, the average flow velocities shown on Figure 3 are considered low even where channel constriction results in higher values. In many of these constricted sections, bedrock either outcrops or has a shallow soil cover, and thus limits the extent of possible erosion. A significant exception is in the vicinity of the Cross-Section 40 where a cemetery is located. Here, an average velocity of 1.8 ft. per sec. would act on a bank consisting of fine silty sand, a material considered very susceptible to erosion. In addition, wave action would cause further erosion. Without protection, it is anticipated that erosion and subsequent sliding would cause loss of the cemetery.

Soils susceptible to erosion occur in a number of bays. These will be subject to relatively still water, apart from that due to wave action. Based on experience at Lac du Bonnet and Pine Falls reservoirs, wave action resulting from winds, will be the primary cause of erosion and instability.

The raising of the water to elevation 847 or 850, in itself has a stabilizing effect on the banks, as the buoyant effect reduces the forces tending to cause sliding.

With regard to wave action erosion, very little published information is available particularly for banks consisting of clays. Under these circumstances a comparative approach is considered the most valid. The experience at the Lac du Bonnet and Pine Falls reservoirs offer comparison based on soils having similar glacio-lacustrine origin. The soils at South Indian Lake are, however, less plastic containing somewhat more silt. This would tend to reduce the cohesive strength and somewhat increase the susceptibility to erosion.

The mean annual temperature of about 26° F at South Indian Lake, compared to Lac du Bonnet of about 34° F, suggests a shorter ice-free season for wave action at South Indian Lake off-setting somewhat the greater susceptibility to erosion. A mean annual temperature of below 32° F, however, introduces the complication of permafrost which may undergo loss of strength when inundated. However, the soil testing program did not indicate extensive permafrost and where permafrost was found, it generally did not show detrimental ice segregation.

Taking these factors into account, the opinion is expressed that erosion rates at South Indian Lake would be comparable to those at Lac du Bonnet and Pine Falls reservoirs. Bank recession rates ranging from 2 to 5 feet per year period were estimated for these reservoirs. This recession is still continuing. It must be stressed, however, that the prediction of rates and extent of erosion of unprotected banks involves many unknown factors. Within the limits of a reasonable budget, it is not possible to determine with sufficient detail such factors as soil strength, micro-climate of individual banks, local seepage conditions, vegetation and other cover, etc. that would permit a prediction of erosion rates for individual banks. It is even more difficult to predict where and when individual eroded banks will subsequently fail by sliding. Exceptions to the predicted rates must be anticipated.

An important finding from the Lac du Bonnet and Pine Falls reservoirs is that rip-rap has been shown to effectively stop the erosion process. This offers a means to protect those areas where protection is deemed necessary.

Some contrast can be made to other reservoir experience. R.O. Van Everdingen(4) and J.P. Coakley and P.F. Hamblin(5) report on experiences at Lake Diefenbaker, Saskatchewan following filling of the reservoir in 1967. Experience has shown that wave action caused by wind has eroded vertical cliffs which then fail by undercutting or by slides occurring after lowering of water levels. Lake Diefenbaker has undergone rather dramatic erosion attributable to relatively high banks and to the presence of glacial tills which have a columnar jointing that breaks off on vertical faces. Such severe action is not anticipated at South Indian Lake Settlement. The sinuous nature of the shoreline and the presence of islands will dampen the wave action and high resistant bedrock outcrops in numerous locations will limit erosion. As can be seen from Table 2, the lake level will undergo very little variation. This precludes the possibility of rapid draw-down slides. The banks in general are relatively low.

PROPOSED SET-BACK CRITERIA

The studies undertaken for Manitoba Hydro have reached the stage where criteria have been established for determining the location of a set-back line. A proposed but yet to be finalized set-back line is shown on Figure 7A. The set-back line represents recognition of the total effects of raised water levels on the shoreline. The following were considered in the development of set-back criteria.

(1) The results of cross-sections, test borings and soil tests. Typical results are shown on Figures 5-1 to 5-3 representing conditions in the vicinity of the proposed community center.

(2) A shoreline classification based on visual observation as shown on Figure 3. Examination was made off-shore by boat, from above by helicopter, and by field traverse.

(3) A study of the shoreline erosion on the Lac du Bonnet and Pine Falls reservoirs where geologically comparable soil deposits are found. Account was taken of considerably different ground temperature conditions. A major similarity at South Indian Lake to these southern reservoirs is that wind will result in wave action being the major cause of erosion.

(4) The lake will be raised initially to elevation approximately 847. Ice, wave action, etc. would give an upper foreshore elevation of 850. It is possible that subsequent operation demands may require the level to be raised to elevation 850. A corresponding upper foreshore elevation of 853 was assumed.

Proposed development of South Indian Lake Settlement can be affected by the raised water levels in a number of ways. These effects can be related either directly to elevation, or to erosion of the new shoreline. On this basis the following criteria were proposed:

A. Use of the 860 Contour

Raising of the lake to possibly as high as elevation 850, will cause changes in the water table in the adjacent bank, and alter drainage. Wave uprush, wind set, etc. can give temporary rise above elevation 850. Where raised levels cover permafrost or near permafrost, they will cause permafrost recession and associated effects. Drilling indicated permafrost at a number of sites, although most test holes near the water's edge showed no permafrost.

A boundary beyond which such effects are minimal can be based primarily on elevation. For the purposes of South Indian Lake Community, the 860 contour was recommended. This provides an adequate 10 to 13 feet height above proposed revised water levels to assure drainage and minimal effects from a raised water table. Reasonably reliable contour information is available for the five feet contour intervals, which include the 860 contour. This is a practical advantage over using some intermediate value.

The 860 contour can be taken for the boundary in those areas where bedrock outcrops at elevation 860. This is shown in Case D on Figure 6A. The boundary can be taken just above elevation 860 in the somewhat similar Case C.

The 860 contour can be taken for the boundary in those areas where the contour is well removed from the raised shoreline, such as in saddle areas between adjacent high ground. These cases are shown as Case E and Case G on Figure 6B.

The above criteria based on contour 860 would govern for most of South Indian Lake Community. However, for a greater part of the presently built-up areas, or areas for planned expansion, shoreline conditions impose a criteria based on erosion and sliding.

B. Use of Erosion and Sliding Criteria

To determine a boundary up to which erosion and sliding take place, it is convenient to consider the area involved to consist of foreshore, a back slope and a supplementary set-back distance. These are obtained as follows:

(1) The foreshore consists of an erosion shelf. Based on the data from the Lac du Bonnet and Pine Falls reservoirs, it was assumed that the erosion shelf would commence about 5 feet below raised water levels. Conservatively, this was taken below the lower future elevation of 847. Had elevation 850 been used, a narrower erosion shelf would have resulted.

The erosion shelf rises at a slope of 14 horizontal to 1 vertical, a value which corresponds to the existing foreshore slope, and is slightly less than the 5 degree slope found on the Lac du Bonnet and Pine Falls foreshore.

Wave uprush was considered to extend the foreshore to elevation 853, conservatively 3 feet above the higher possible lake level. The erosion shelf width on this basis is 154 feet.

(4) The back slope was taken at 4 horizontal to 1 vertical. This value is consistant for a residual angle of internal friction of about 20° estimated from plasticity index values, and assuming a safety factor just sufficient for equilibrium under conditions of some seepage.

(3) A supplementary set-back distance was established to provide for back slope safety factor, and an access area to the bank located entirely on the hydro reserve. The rate of erosion shelf development at Lac du Bonnet and Pine Falls ranged between 2 to 5 feet per year over a 20 year period. A set-back distance of 100 feet was suggested to give an additional erosion life of not less than 20 years assuming comparable rates. This life would be in addition to the approximately 30 years it would take

to erode the 154 feet width of erosion shelf for a total of about 50 years. The calculations must be regarded as very approximate, but they do indicate the advantage of the supplementary set-back. The supplementary set-back distance can be made greater if greater assurance of reserve life is desired. The supplementary set-back is not required where bedrock definitely limits the erosion shelf development. Two such cases include Cases C and D of Figure 6A.

Figures 6A and 6B show the application of the erosion and sliding criteria for various conditions. It must be noted that the criteria assume that no action is taken to prevent erosion. Experience at Lac du Bonnet and Pine Falls definitely shows that the process can be halted by the use of rip-rap. It also can stop naturally when presence of boulders and gravel in the eroding material form a natural protection.

DISCUSSION OF SET-BACK CRITERIA

Practical consideration also affect the establishment of the set-back line. Figure 7A shows the set-back line superimposed on a contour plan of South Indian Lake Settlement. It becomes apparent that the geometry involved has to be simplified in certain locations simply to permit a geometry that can readily be established in the field. It is also apparent that in certain locations, areas delineated by strict adherence of the criteria are too small or of impractical shape to be practical. In this regard, it was recommended that the Manitoba Hydro simplify the geometry on the basis of their experience at other reservoirs.

It should also be noted that not all areas within the set-back are necessarily unsuitable for development. For example rip-rap protection can be used to protect clay banks from erosion. In certain areas the occurrence of bedrock at higher elevations then those indicated by the limited drilling program, can permit development somewhat closer to the water. In low lying areas, development may be possible if fill were used to give higher ground. However, it would be imprudent to develop any such area without an engineering investigation of detailed local conditions beyond the scope of the present study.

Examination of new housing and other buildings at South Indian Lake shows that surface footings were designed with little regard if any to permafrost or other soil conditions. The experience of developing a northern community, for example at Thompson, would indicate that serious foundation problems will result, which have no relation at all to raised water levels. This should be brought to the attention of housing officials in order to avoid future misunderstanding as well as to assure more permanent buildings.

It should also be pointed out that set-back criteria remove from development areas that are not suited for development even if the lake level were not raised, for example heavy permafrost and muskeg areas, below contour 860. It should not, therefore, be interpreted that such areas above 860 are satisfactory for development. They are not suitable either now or later.

CONCLUSIONS

The effects on the shoreline at South Indian Lake Settlement due to raised water levels are anticipated in the establishment of a set-back line. The set-back line will be established by Manitoba Hydro and its purpose is to limit construction to those areas which are beyond foreseeable effects of raised water levels, erosion and sliding. Proposals for community center, homes, roadways, electric power, etc. involve the establishment of facilities previously non-existent, or of a much more technically advanced nature. These proposals, some of which are currently underway, have taken into account the raised lake level. Although not within the terms of reference, the writers' background in engineering and education makes it necessary to point out a very real need the visits to the sites have demonstrated. Technically trained local people will be required to service the community's greatly changed and increased technical needs. These needs arise from the work that is necessary in building roadways, bank protective measures, etc. Trained personnel are required for construction and maintenance of buildings, water lines, sewage treatment plant, etc. Such training has started with regard to house building, but is required on a much broader scale. A program with the University of Manitoba, Civil Engineering Department may be a possible way to provide training.

Attention is drawn to the fact that winter lake conditions may involve weak ice, and open water in certain areas, with attendent risk in across-ice travel. Other hydraulic factors considered include water velocities at constricted sections in the narrows, and back eddies in bays which may lead to an accumulation of floating logs and other debris.

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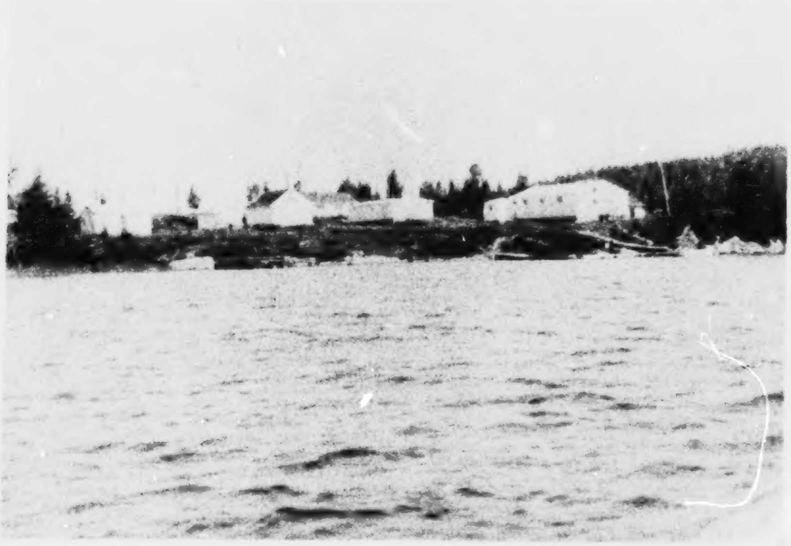
PHOTOGRAPH 1 - Aerial view of South Indian Lake Settlement. This view from the south shows the populated shoreline on both sides of the narrows and a number of small islands.

PHOTOGRAPH 2 - Aerial view of the area designated for community center development. Existing church, community hall, permanent and mobile homes, and wharf on east shoreline are shown.

PHOTOGRAPH 3 - Aerial view of existing trading post, nursing station and homes on west shoreline of narrows.



PHOTOGRAPH 4 - View from boat of four buildings shown on extreme left of shoreline in Photograph 3.

PHOTOGRAPH 5 - Existing school, mobile and permanent homes on west shoreline. These are located above the proposed raised elevations of 847 and 850 of Southern Indian Lake. Wave action erosion can be expected on those portions of bank consisting of soil unless rip-rap is used.

PHOTOGRAPH 6 - Abandoned church on east shoreline. Ground elevation is about 848 at this site. Raised water levels and shoreline erosion would affect this structure.

PHOTOGRAPH 7 - Shoreline near Cross-Section Line 63. Test holes indicated that a relatively shallow cover of about four feet thick covers underlying bedrock which would eventually be exposed by erosion. The bank would otherwise remain stable.

PHOTOGRAPH 8 - One of two cemeteries located on the east shore. The cemeteries have been located close to the lake for access, and in areas where the soil is easy to excavate. These considerations make the cemetery shown susceptible to erosion and sliding. Before lake levels are raised rip-rap protection or relocation must be considered.

PHOTOGRAPH 9 - Existing beach near community center development on east shore. Similar beaches can be developed eventually at higher elevations. Experience at Lac du Bonnet indicates that man-made beaches can be constructed at anticipated raised shorelines to provide for the immediate need of beaches.

PHOTOGRAPH 10 - The existing permafrost shoreline is sliding as thawing takes place adjacent to water's edge. Raised water levels will speed this process. The bank shown is not near any presently or proposed area for development.

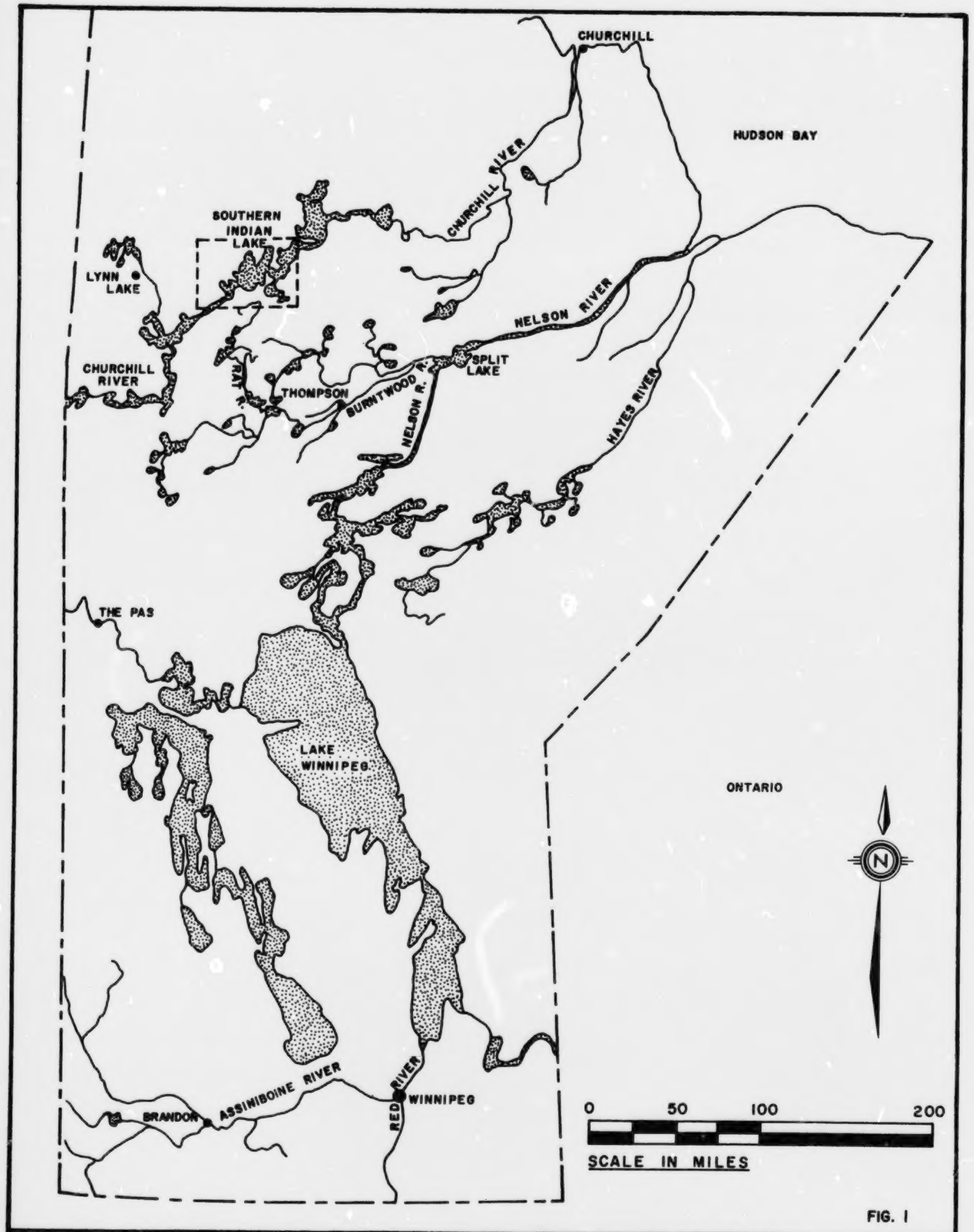

CHURCHILL
HUDSON BAY
CHURCHILL RIVER
SOUTHERN INDIAN LAKE
LYNN LAKE
CHURCHILL RIVER
NELSON RIVER
SPLIT LAKE
RAT R.
THOMPSON
BURNTWOOD
NELSON R.
HAYES RIVER
THE PAS
LAKE WINNIPEG
ONTARIO
N
BRANDON
ASSINIBOINE RIVER
RED RIVER
WINNIPEG
0
50
100
200
SCALE IN MILES

FIG. 1

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

PREPARED S.P.
DRAWN S.P.
CHECKED
SUBMITTED
DATE
APPROVED
DATE

CANADA - MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SOUTH INDIAN LAKE SETTLEMENT
SHORELINE INVESTIGATION
LOCATION PLAN

SCALE AS SHOWN
DATE DEC./73
SHEET 1 OF 23
FILE NO. 61-6-1044

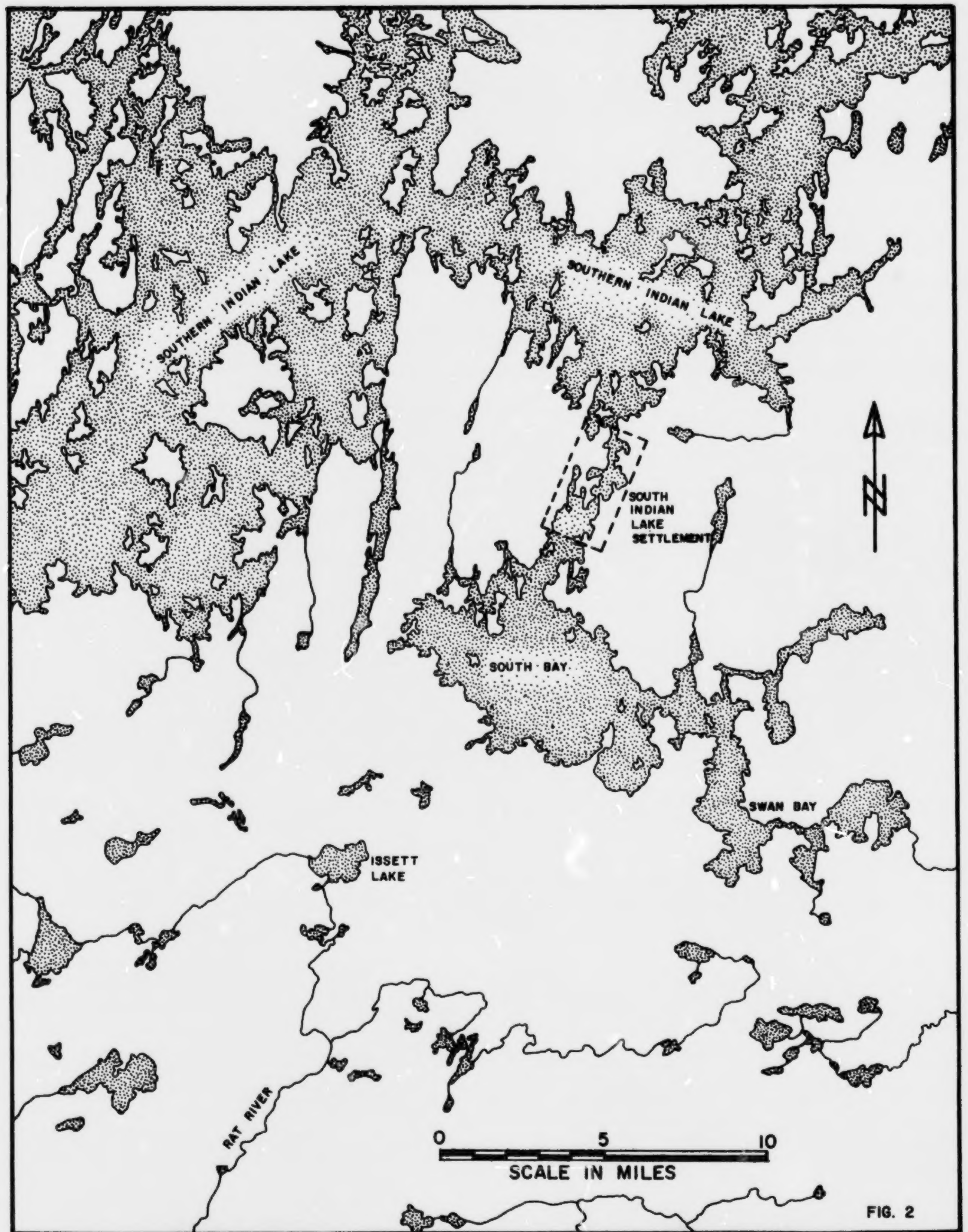

SOUTHERN INDIAN LAKE
SOUTHERN INDIAN LAKE
SOUTH INDIAN LAKE SETTLEMENT
SOUTH BAY
SWAN BAY
ISSETT LAKE
RAT RIVER
N
0
5
10
SCALE IN MILES

FIG. 2

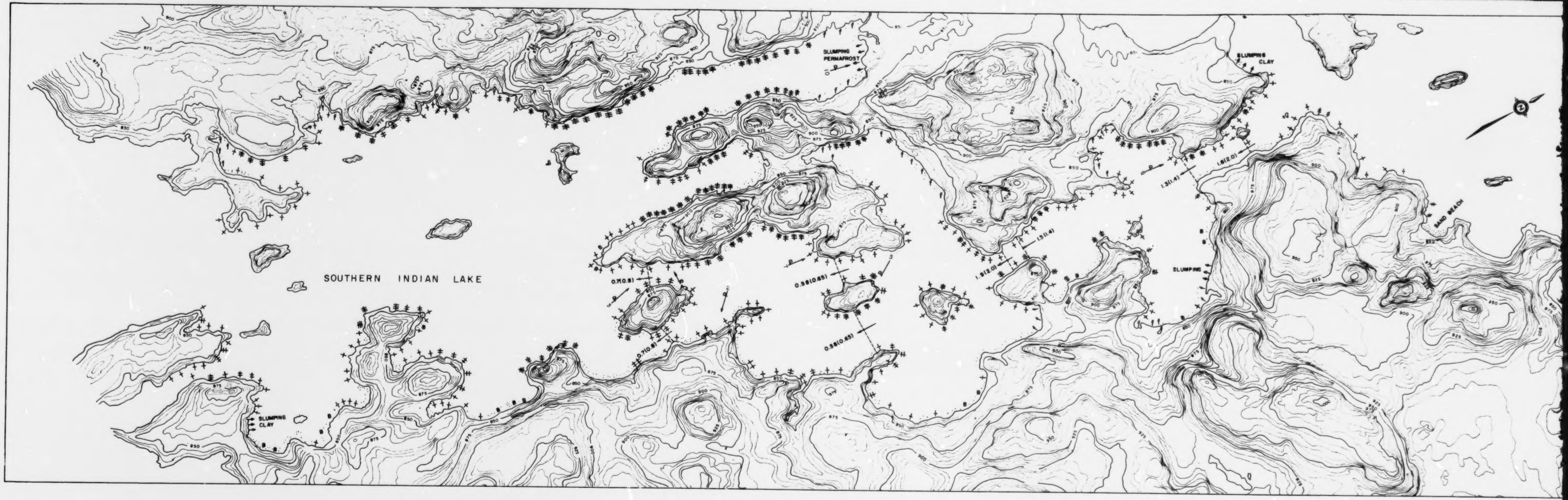
PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

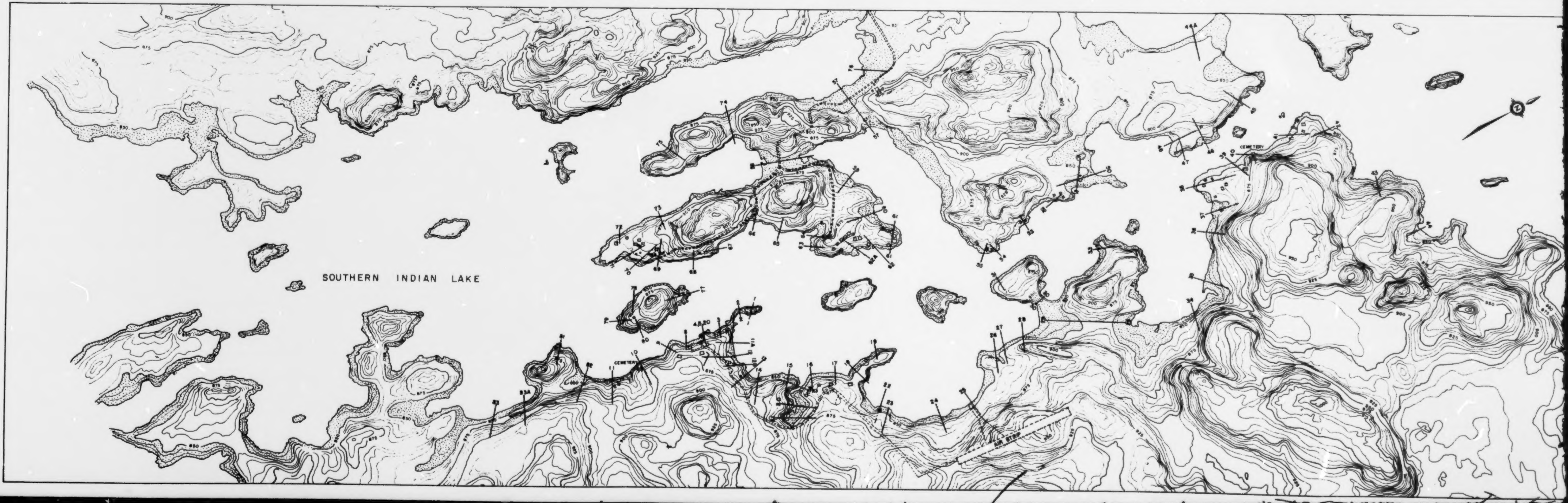
PREPARED S.P.
DRAWN S.P.
CHECKED
SUBMITTED
DATE
APPROVED
DATE

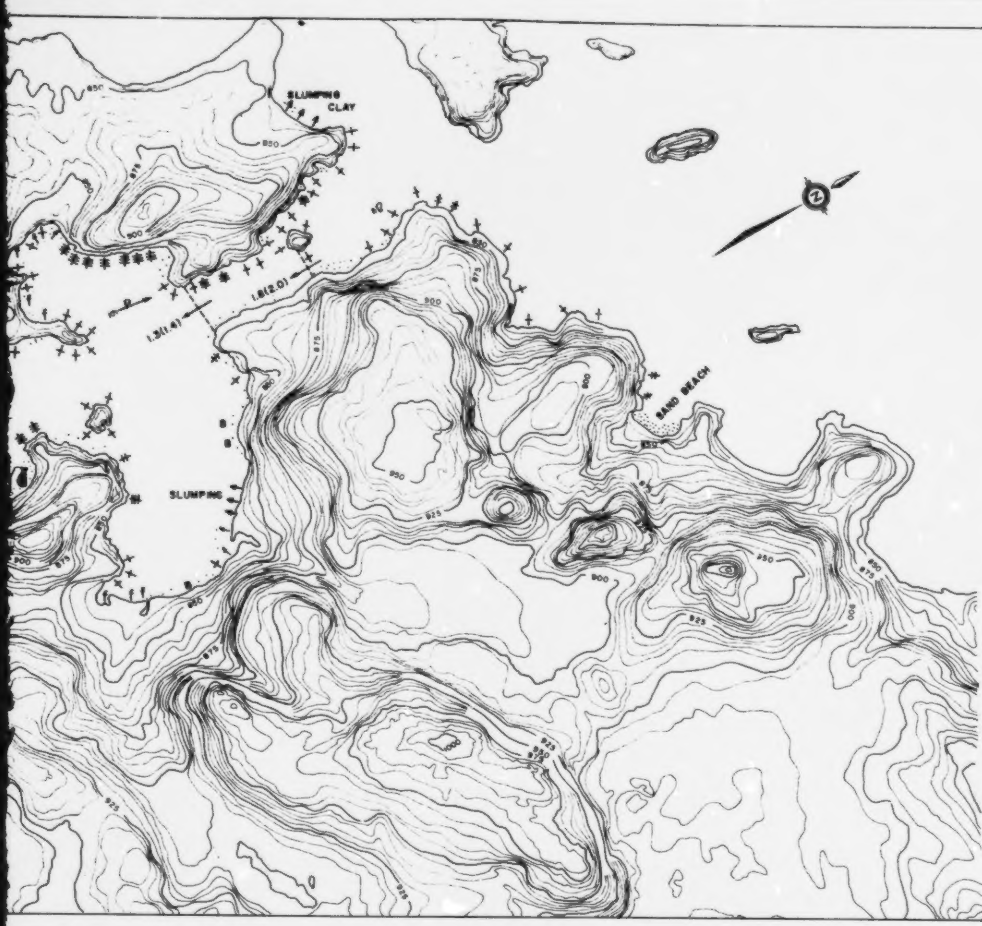
CANADA - MANITOBA
LAKE WINNIPEG CHURCHILL AND NELSON RIVERS STUDY BOARD

SOUTH INDIAN LAKE SETTLEMENT
SHORELINE INVESTIGATION
KEY PLAN

SCALE AS SHOWN
DATE DEC/73
SHEET 2 OF 23
FILE NO. 61-6-1044


SLUMPING PERMAFROST
SLUMPING CLAY
SOUTHERN INDIAN LAKE
SLUMPING
SLUMPING CLAY
SAND BEACH
0.7(0.8)
0.85(0.85)
1.5(1.4)
1.8(2.0)
850
875
900
925
950


SOUTHERN INDIAN LAKE
CEMETERY
CEMETERY
AIR STRIP
850
875
900
925
950


SLUMPING CLAY
SAND BEACH
SLUMPING
1.3(1.4)
1.8(2.0)
850
875
900
925

LEGEND.

- SHORELINE BEDROCK 10'-15' ABOVE WATER
- SHORELINE BEDROCK 5'-10' ABOVE WATER
- SHORELINE BEDROCK 0'-5' ABOVE WATER
- SILT, SAND OR CLAY
- f FEN
- B BOULDERS
- SLUMPING BANK
- PHOTOGRAPH LOCATIONS (ARROW INDICATES DIRECTION OF VIEW)
- 1.8(2.0) AVERAGE VELOCITY, FEET/SECOND, FOR LAKE LEVEL AT ELEVATION 847, OPEN WATER (FLOW UNDER 3 FEET OF ICE)

SCALE IN FEET 0 1000 2000 2500 3000

FIG 3

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA - MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SOUTH INDIAN LAKE SETTLEMENT
SHORELINE INVESTIGATION
SHORELINE CLASSIFICATION AND PHOTOGRAPH LOCATIONS

SCALE	DATE	SHEET NO.	FILE NO.
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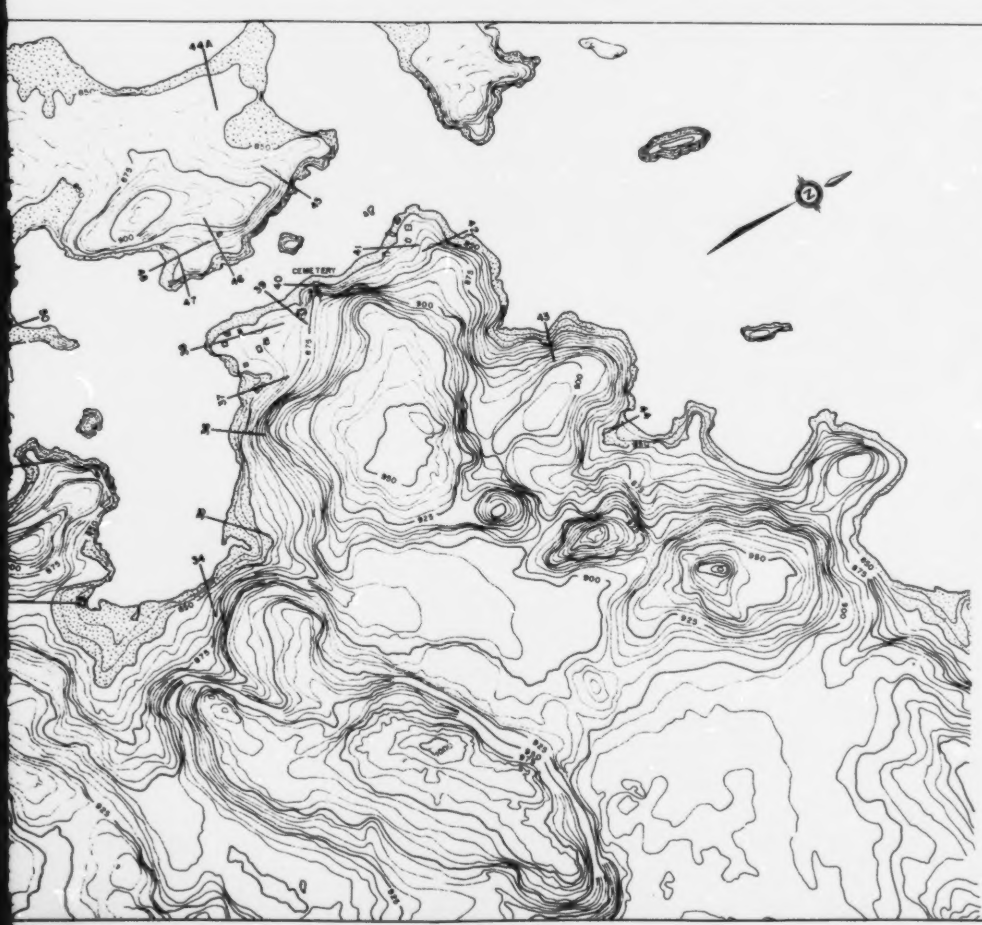
44A
CEMETERY
850
875
900
925

LEGEND

- NO AND LOCATION OF CROSS SECTION
- AREA INUNDATED BY RAISING LAKE LEVEL TO ELEV 850'
- CEMETERY
- BUILDINGS
- ROADWAY

SCALE IN FEET 0 1000 2000 2500 3000

FIG. 4

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA - MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SOUTH INDIAN LAKE SETTLEMENT
SHORELINE INVESTIGATION
AREA INUNDATED BY RAISING LAKE LEVEL TO ELEVATION 850
LOCATION OF CROSS-SECTION LINES
CONTOURS FROM WESTERN PHOTOGRAMMETRY 1967 MAPPING

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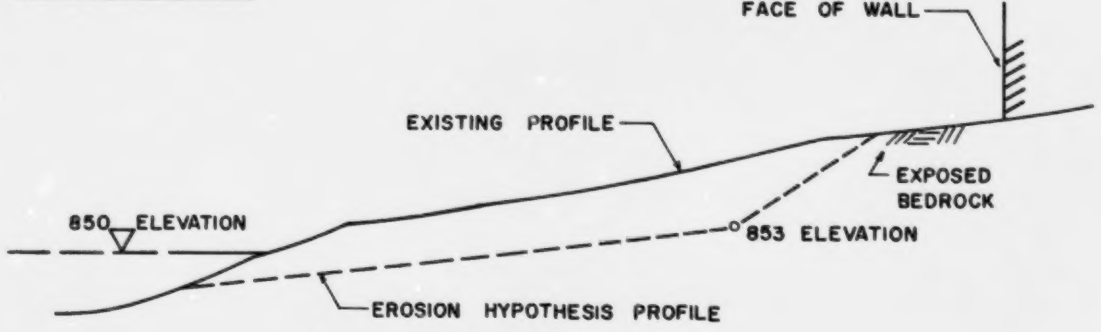
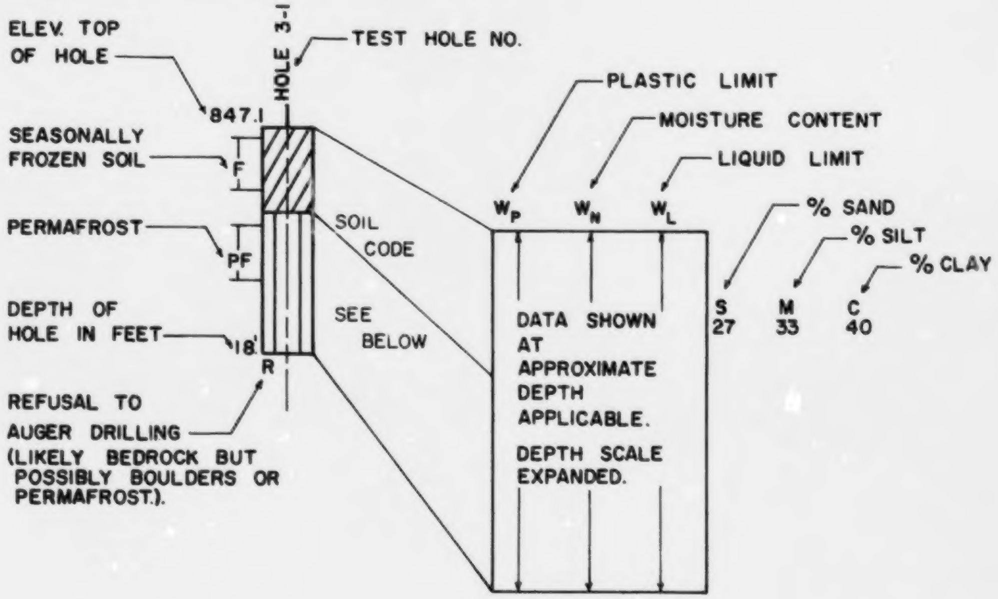
PROFILE LEGEND


FACE OF WALL
EXISTING PROFILE
EXPOSED BEDROCK
850 ELEVATION
853 ELEVATION
EROSION HYPOTHESIS PROFILE

TEST HOLE SYMBOLS


ELEV. TOP OF HOLE
HOLE 3-1
TEST HOLE NO.
847.1
SEASONALLY FROZEN SOIL
F
PERMAFROST
PF
DEPTH OF HOLE IN FEET
18'
R
REFUSAL TO AUGER DRILLING (LIKELY BEDROCK BUT POSSIBLY BOULDERS OR PERMAFROST.).
SOIL CODE
SEE BELOW
PLASTIC LIMIT
MOISTURE CONTENT
LIQUID LIMIT
W_P
W_N
W_L
DATA SHOWN AT APPROXIMATE DEPTH APPLICABLE.
DEPTH SCALE EXPANDED.
% SAND
% SILT
% CLAY
S 27
M 33
C 40

SOIL CODE

CH - CLAY HIGH PLASTICITY
CI - CLAY INTERMEDIATE PLASTICITY
CL - CLAY LOW PLASTICITY
M - SILT
OH - HIGHLY ORGANIC
C - CLAY

ML - CLAYEY SILT, LOW PLASTICITY
SM - SILTY SAND
S - SAND
G - GRAVEL
Pt - PEAT

FIG. 5

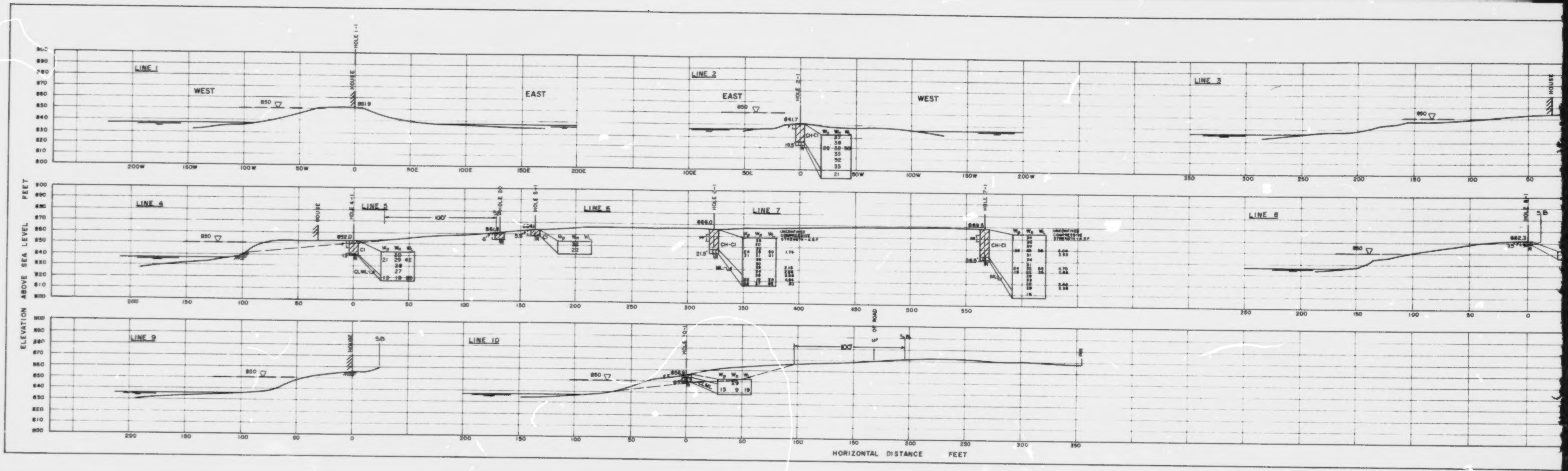
PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA — MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

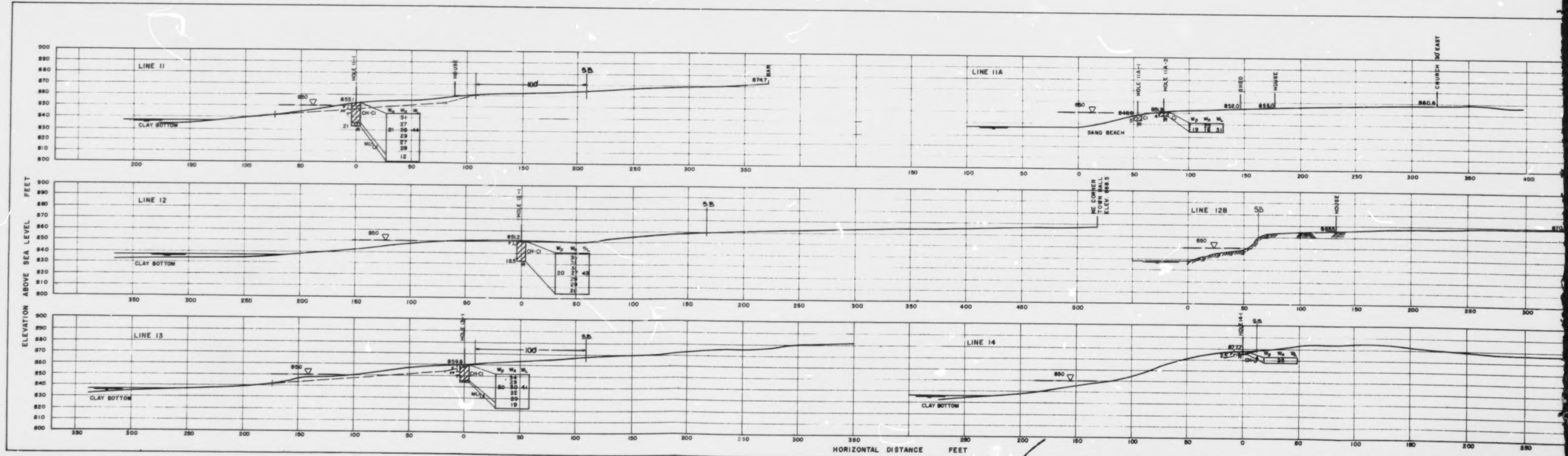
SOUTH INDIAN LAKE SETTLEMENT
SHORELINE INVESTIGATION
PROFILE LEGEND, TEST HOLE SYMBOLS
AND SOIL CODE FOR FIGURES 5-1 TO 5-14.

PREPARED	DRAWN	SUBMITTED	APPROVED
9.B.	S.P.		
	CHECKED	DATE	DATE

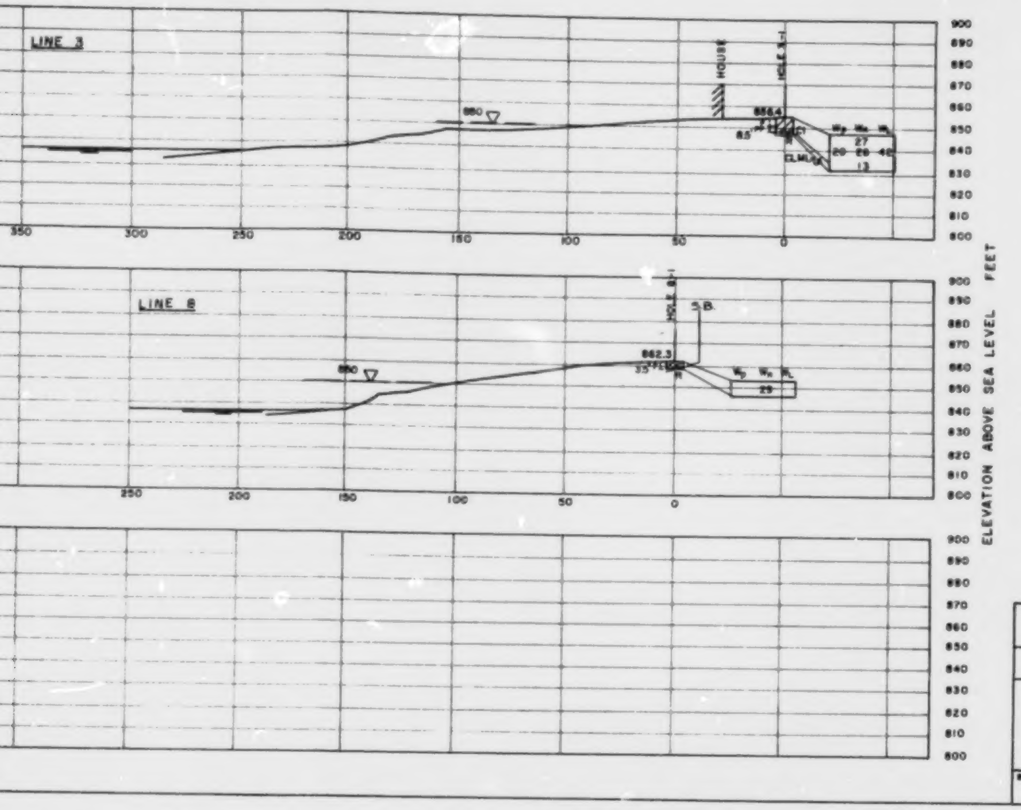
SCALE	DATE	SHEET	FILE NO.
AS SHOWN	DEC./73	5 OF 23	61-6-1044



LINE 1
WEST
EAST
HOLE 1-1
HOUSE
851.9
850
LINE 2
EAST
WEST
HOLE 2-1
841.7
CH-CI
LINE 3
HOUSE
LINE 4
HOUSE
HOLE 4-1
LINE 5
100'
HOLE 5-1
LINE 6
HOLE 6-1
LINE 7
865.0
UNCONFINED COMPRESSIVE STRENGTH - K.S.F.
HOLE 7-1
859.5
LINE 8
HOLE 8-1
862.3
SB
LINE 9
HOUSE
SB
LINE 10
HOLE 10-1
100'
℄ OF ROAD
SB
W_p
W_n
W_L
CH-CI
ML
ELEVATION ABOVE SEA LEVEL FEET
HORIZONTAL DISTANCE FEET



LINE 11
HOLE 11-1
HOUSE
100'
SB
874.7
BARN
853.1
CH-CI
CLAY BOTTOM
LINE 11A
HOLE 11A-1
HOLE 11A-2
SHED
HOUSE
CHURCH 30' EAST
852.0
855.0
860.6
SAND BEACH
LINE 12
HOLE 12-1
851.2
SB
NE CORNER TOWN HALL ELEV. 868.5
CLAY BOTTOM
LINE 12B
SB
HOUSE
LINE 13
HOLE 13-1
100'
SB
859.8
CH-CI
CLAY BOTTOM
LINE 14
HOLE 14-1
SB
877.7
CLAY BOTTOM
W_p
W_n
W_L
ELEVATION ABOVE SEA LEVEL FEET
HORIZONTAL DISTANCE FEET



NOTE: ELEVATION OF SOUTHERN INDIAN LAKE AT TIME OF SURVEY WAS 837'

NOTE: ALL LINES MARKED WITH A 1/2" DIAMETER RE-BAR BEARING A ROUND BRONZE IDENTIFICATION TAG

NOTE: ALL ELEVATIONS BASED ON WATER SURVEY OF CANADA BENCH MARK HAVING ELEVATION 839.58' AND LOCATED 20' WEST AND 3' NORTH OF M.G.A.S. DOCK

NOTE: TEST HOLES DRILLED JULY AND AUGUST 1973 3-INCH DIAMETER POWER AUGER USED

SOIL LEGEND:

▤	ORGANIC	▦	GRAVEL
▨	CLAY	▦	BOULDERS
▥	SILT	▨	ROCK (FRACTURED)
☐	SAND	■	ROCK (SOLID)

NOTE: FOR EXPLANATION OF CODED SOILS DESCRIPTION TEST RESULTS, PERMAFROST OCCURRENCE AND OTHER SYMBOLS REFER TO FIGURE 5.

FIG. 5-1

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA - MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SOUTH INDIAN LAKE SETTLEMENT
SHORELINE INVESTIGATION
CROSS-SECTIONS LINES 1 TO 9
TEST HOLE LOGS

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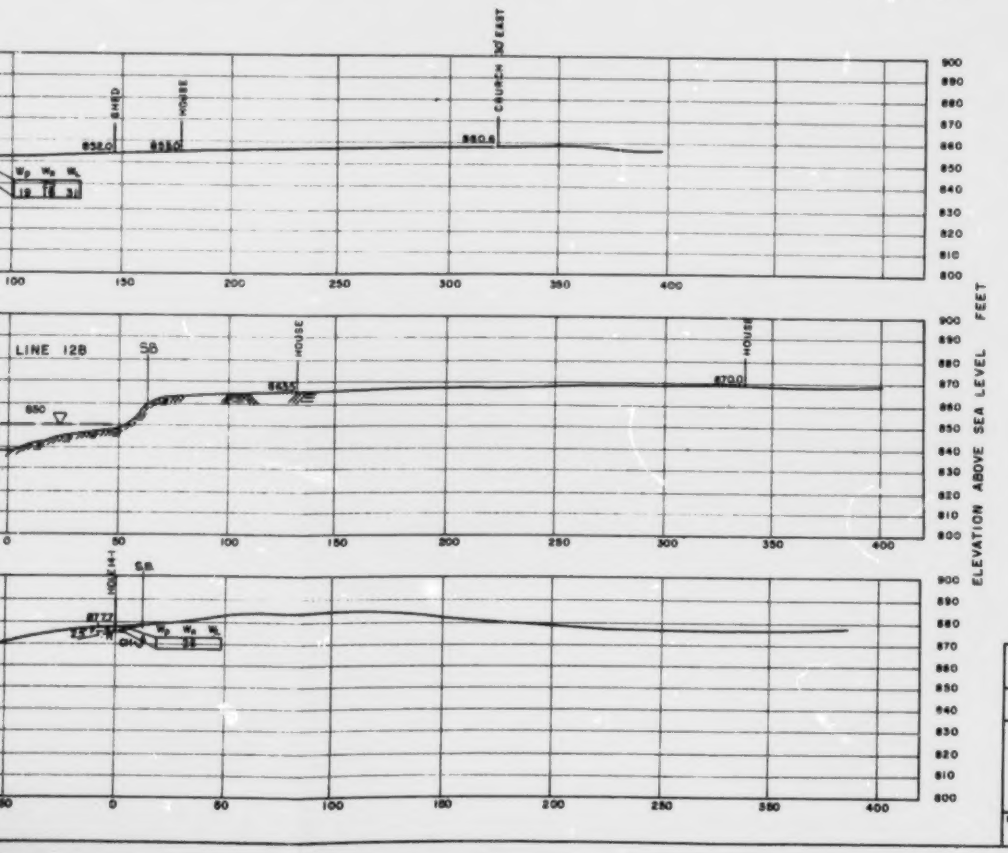

NOTE: ELEVATION OF SOUTHERN INDIAN LAKE AT TIME OF SURVEY WAS 837'

NOTE: ALL LINES MARKED WITH A 1/2" DIAMETER RE-BAR BEARING A ROUND BRONZE IDENTIFICATION TAG

NOTE: ALL ELEVATIONS BASED ON WATER SURVEY OF CANADA BENCH MARK HAVING ELEVATION 839.58' AND LOCATED 20' WEST AND 3' NORTH OF M.G.A.S. DOCK

NOTE: TEST HOLES DRILLED JULY AND AUGUST 1973 3-INCH DIAMETER POWER AUGER USED.

SOIL LEGEND:

▤	ORGANIC	▦	GRAVEL
▨	CLAY	▦	BOULDERS
▥	SILT	▨	ROCK (FRACTURED)
☐	SAND	■	ROCK (SOLID)

NOTE: FOR EXPLANATION OF CODED SOILS DESCRIPTION TEST RESULTS, PERMAFROST OCCURRENCE AND OTHER SYMBOLS REFER TO FIGURE 5.

FIG. 5-2

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA - MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SOUTH INDIAN LAKE SETTLEMENT
SHORELINE INVESTIGATION
CROSS-SECTIONS LINES 11 TO 14
TEST HOLE LOGS

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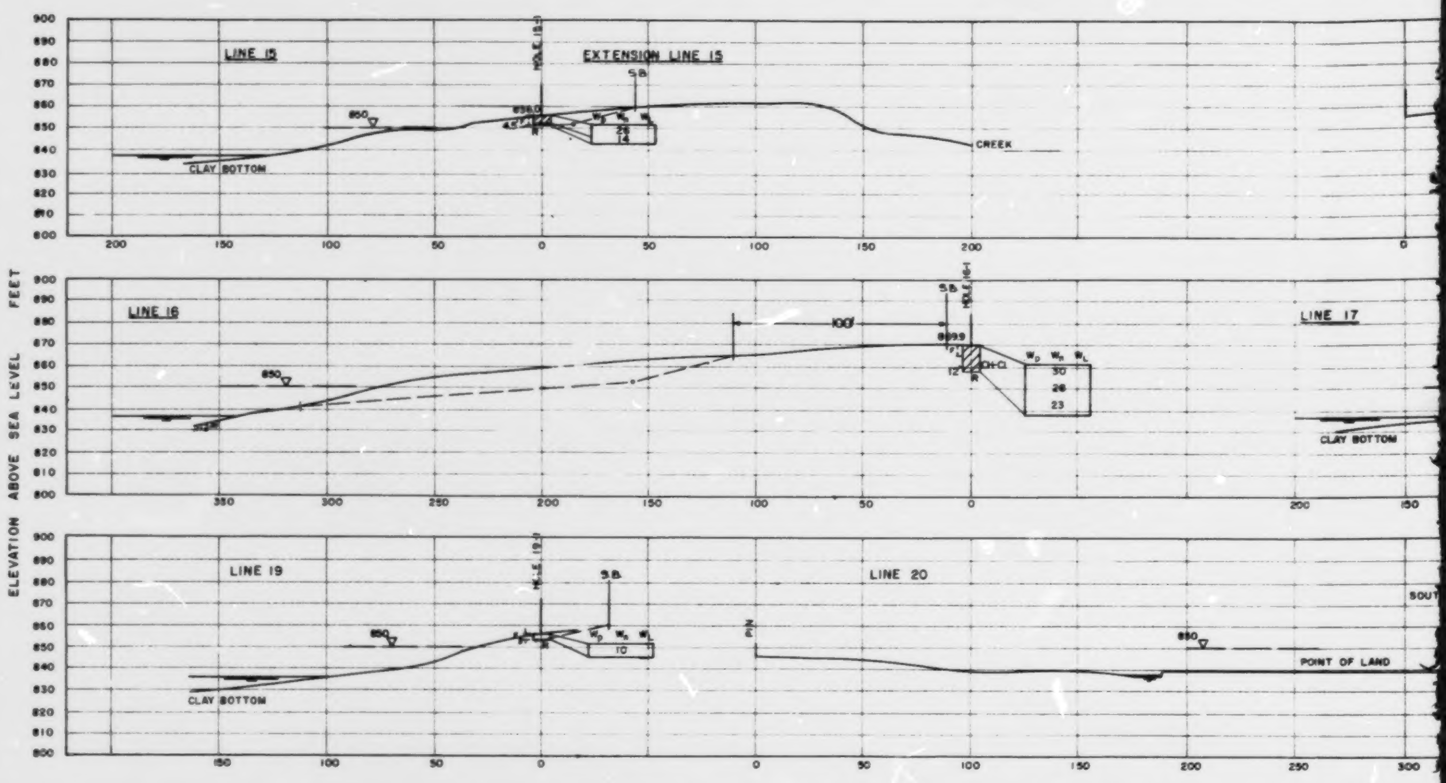
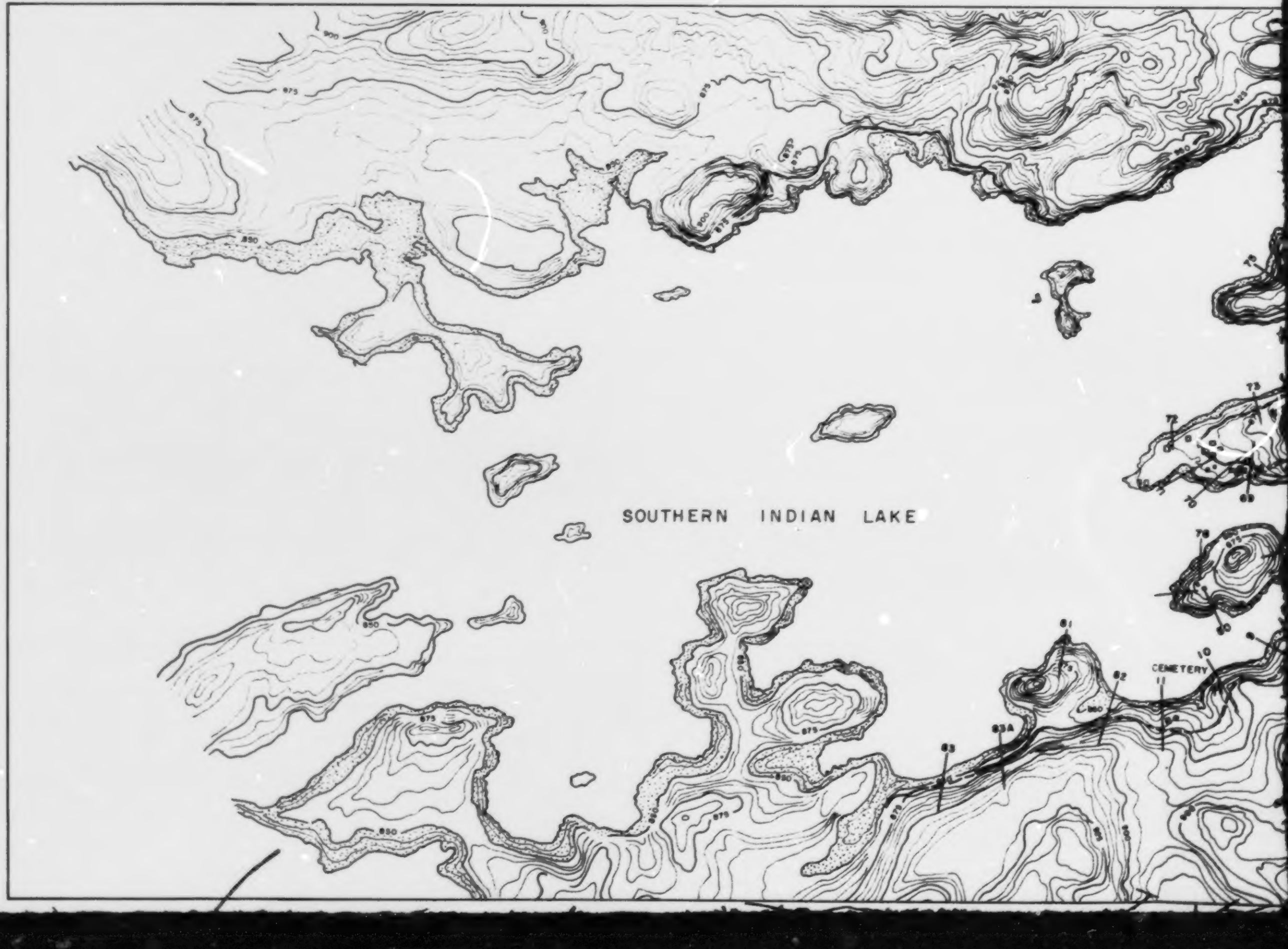
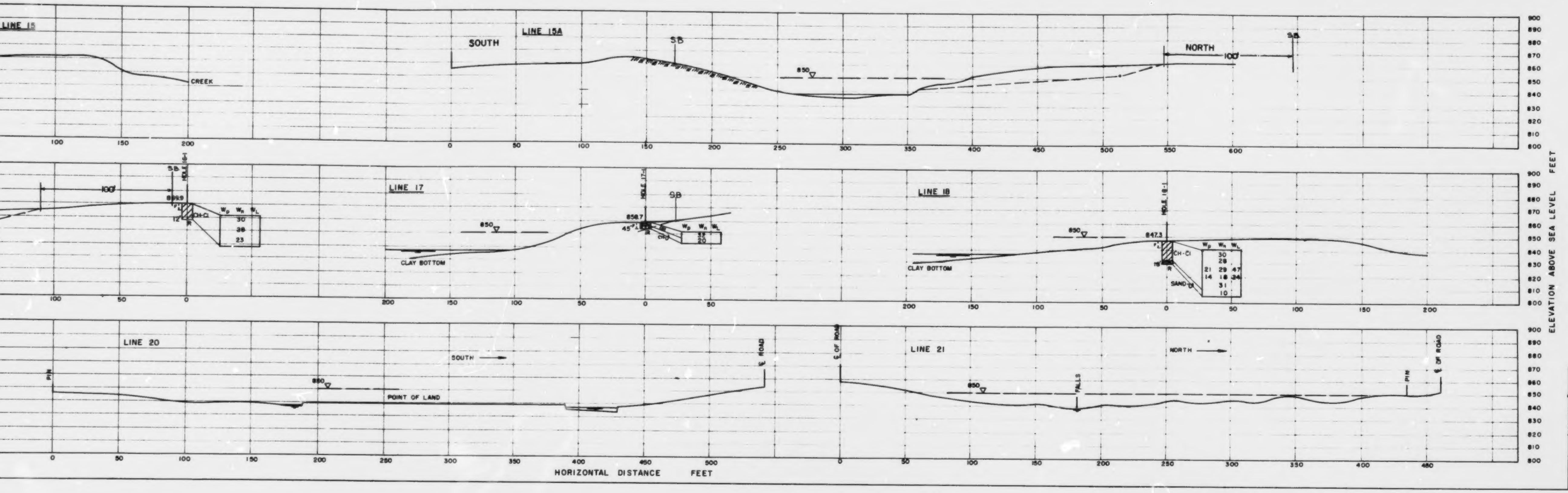
AS SHOWN	DEC./73	7 OF 23	61-6-1044







NOTE: ELEVATION OF SOUTHERN INDIAN LAKE AT TIME OF SURVEY WAS 837'

NOTE: ALL LINES MARKED WITH A 1/2" DIAMETER RE-BAR BEARING A ROUND BRONZE IDENTIFICATION TAG

NOTE: ALL ELEVATIONS BASED ON WATER SURVEY OF CANADA BENCH MARK HAVING ELEVATION 839.58' AND LOCATED 20' WEST AND 3' NORTH OF M.G.A.S. DOCK

NOTE: TEST HOLES DRILLED JULY AND AUGUST 1973 3-INCH DIAMETER POWER AUGER USED

SOIL LEGEND:

▤	ORGANIC	▦	GRAVEL
▨	CLAY	▦	BOULDERS
▥	SILT	◩	ROCK (FRACTURED)
□	SAND	■	ROCK (SOLID)

NOTE: FOR EXPLANATION OF CODED SOILS DESCRIPTION TEST RESULTS, PERMAFROST OCCURRENCE AND OTHER SYMBOLS REFER TO FIGURE 5.

FIG. 8-3

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA - MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SOUTH INDIAN LAKE SETTLEMENT
SHORELINE INVESTIGATION
CROSS-SECTIONS LINES 15 TO 21
TEST HOLE LOGS

SCALE	DATE	SHEET NO	FILE NO
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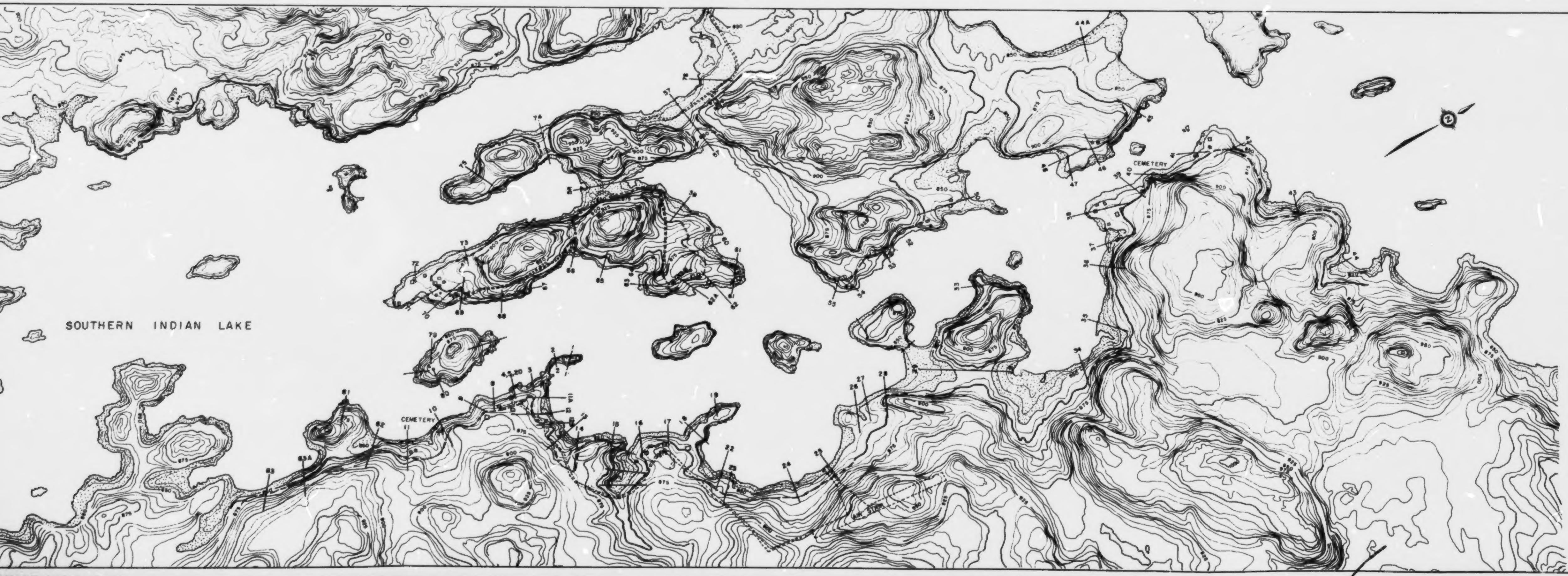

LEGEND:

- NO AND LOCATION OF CROSS SECTION
- AREA INUNDATED BY RAISING LAKE LEVEL TO ELEVATION 850'
- CEMETERY
- BUILDINGS (LOCATIONS APPROXIMATE FROM 1967 AERIAL PHOTOGRAPHS)
- ROADWAY (UNIMPROVED)
- PROPOSED DEVELOPMENT SETBACK LINE: BASED ON ELEVATIONS 860 CONTOURS CRITERIA
- BASED PRIMARILY ON EROSION, SLIDING AND SUPPLEMENTARY SAFETY ALLOWANCE CRITERIA. (IN SOME LOCATIONS AS REQUIRED BY ADDITIONAL NEED FOR SIMPLIFIED GEOMETRY)

SCALE IN FEET 0 1000 2000 2500 3000

NOTE: CONTOURS FROM WESTERN PHOTOGRAMMETRY 1967 MAPPING.

FIG. 7A

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

CANADA - MANITOBA
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SOUTH INDIAN LAKE SETTLEMENT
SHORELINE INVESTIGATION
AREA INUNDATED BY RAISING LAKE LEVEL TO ELEVATION 850
LOCATION OF CROSS-SECTION LINES
PROPOSED DEVELOPMENT SETBACK LINE

SCALE	DATE	SHEET NO.	FILE NO.
AS SHOWN	DEC./73	23 OF 23	61-6-1044

PROPOSED DEVELOPMENT SETBACK LINE

HIGH BANK – WITHOUT AND WITH BEDROCK CONTROL.

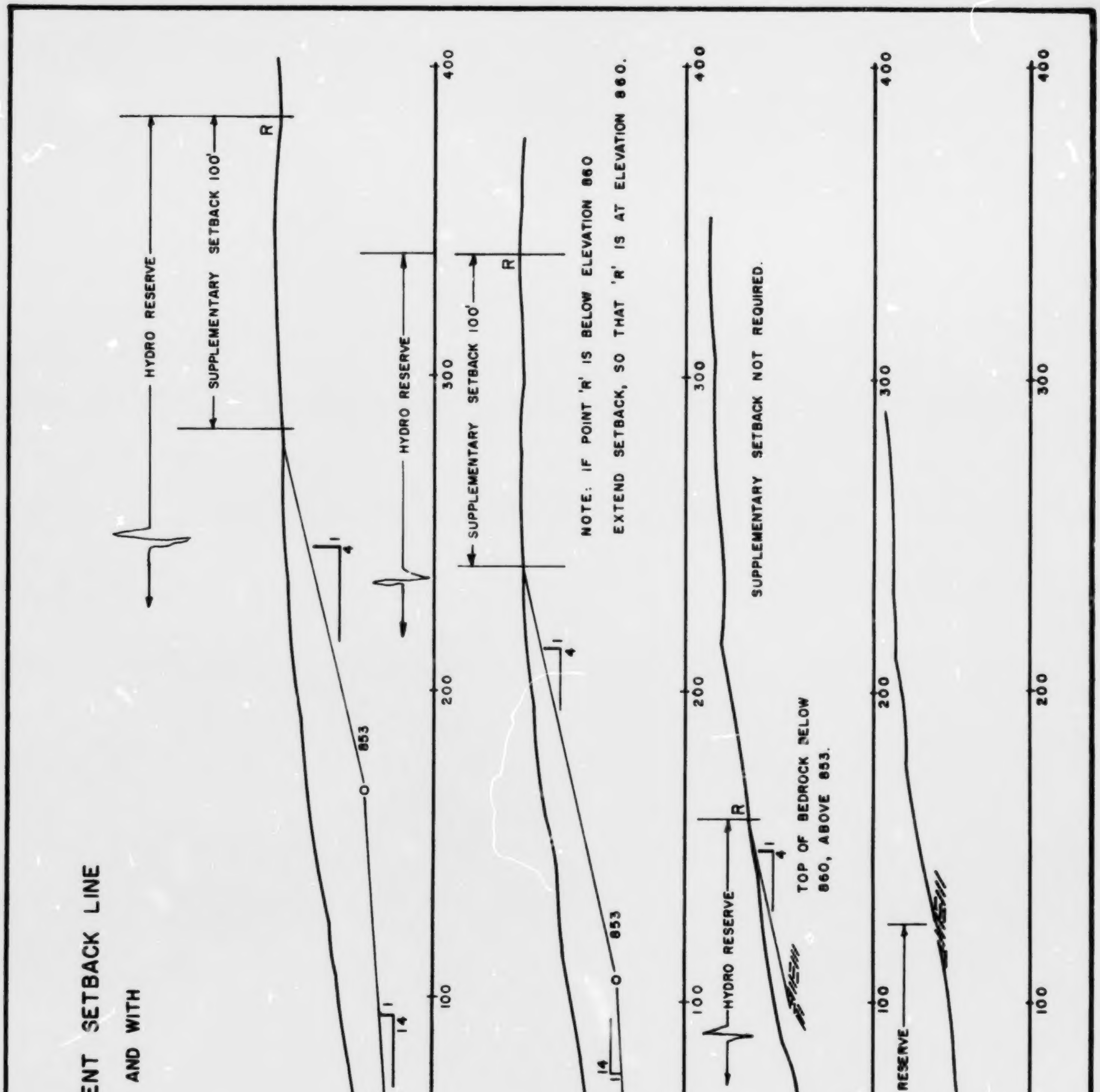
CASE A
CASE B
CASE C
CASE D
860
850
840
0
100
200
300
400
853
1
14
1
4
R
HYDRO RESERVE
SUPPLEMENTARY SETBACK 100'
NOTE: IF POINT 'R' IS BELOW ELEVATION 860 EXTEND SETBACK, SO THAT 'R' IS AT ELEVATION 860.
SUPPLEMENTARY SETBACK NOT REQUIRED.
TOP OF BEDROCK BELOW 860, ABOVE 853.

FIG. 6A

PROVINCE OF MANITOBA	CANADA – MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT	LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD
WATER RESOURCES BRANCH	SOUTH INDIAN LAKE SETTLEMENT SHORELINE INVESTIGATION CRITERIA FOR DEVELOPMENT SETBACK LINE

PREPARED A.B	DRAWN S.P	SUBMITTED	APPROVED
	CHECKED	DATE 10-12-73	DATE

SCALE AS SHOWN	DATE DEC./73	SHEET 20 OF 23	FILE NO. 61-6-1044

PROPOSED DEVELOPMENT SETBACK LINE

LOW BANK - NO BEDROCK CONTROL

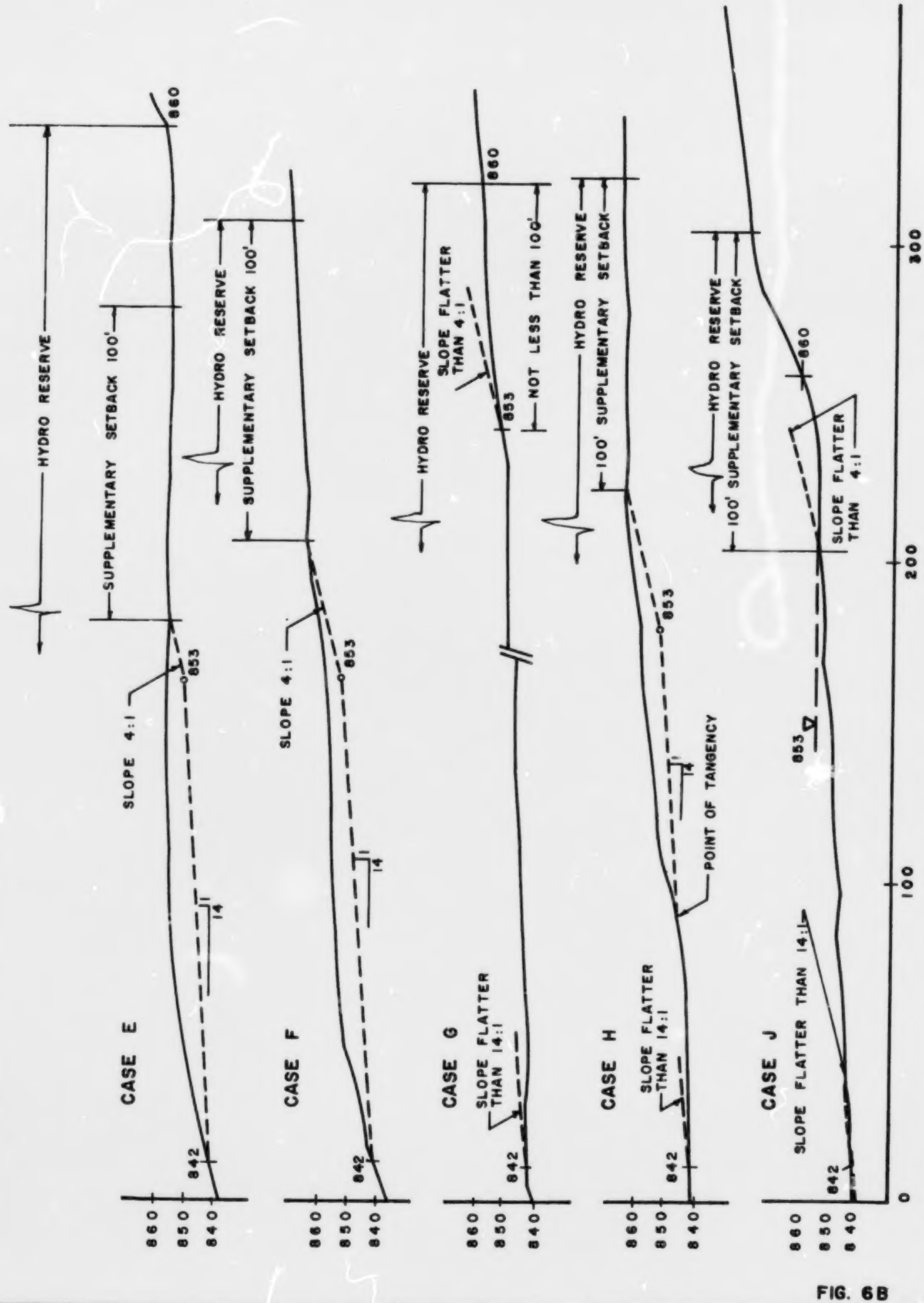
CASE E
CASE F
CASE G
CASE H
CASE J
860
850
840
842
853
860
SLOPE 4:1
1
14
HYDRO RESERVE
SUPPLEMENTARY SETBACK 100'
SLOPE FLATTER THAN 14:1
SLOPE FLATTER THAN 4:1
NOT LESS THAN 100'
100' SUPPLEMENTARY SETBACK
POINT OF TANGENCY
SLOPE FLATTER THAN 14:1
0
100
200
300

FIG. 6B

PROVINCE OF MANITOBA

DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

WATER RESOURCES BRANCH

PREPARED A.B.
DRAWN S.P.
CHECKED
SUBMITTED KP
DATE 10 12-73
APPROVED
DATE

CANADA - MANITOBA

LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SOUTH INDIAN LAKE SETTLEMENT

SHORELINE INVESTIGATION

CRITERIA FOR DEVELOPMENT SETBACK LINE

SCALE AS SHOWN
DATE DEC./73
SHEET 21 OF 23
FILE NO. 61-6-1044

APPENDIX 4 - I

WATER SUPPLY AND SEWAGE DISPOSAL FACILITIES OF CROSS LAKE AND NORWAY HOUSE

WATER SUPPLY AND SEWAGE DISPOSAL FACILITIES
OF
CROSS LAKE AND NORWAY HOUSE

by

A. B. SPARLING
Department of Civil Engineering
University of Manitoba
June, 1973

sub-contracted by:

ENVIRONMENTAL MANAGEMENT DIVISION
Department of Mines, Resources and Environmental Management

for

THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SPECIAL NOTE

THE CONCLUSIONS AND RECOMMENDATIONS CONTAINED IN THIS APPENDIX ARE THOSE OF THE AUTHOR(S) AND ARE NOT NECESSARILY THE SAME AS THE CONCLUSIONS AND RECOMMENDATIONS OF THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD AS EXPRESSED IN THE SUMMARY REPORT AND THE TECHNICAL REPORT.

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CROSS LAKE . . . . Page 11

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COMMUNITY WATER SUPPLY, LAKE WINNIPEG AND OUTLET LAKES

LAKE WINNIPEG, CHURCHILL AND NELSON RIVER STUDY

INTRODUCTION

OBJECTIVE

The objective of this present study is to evaluate the effects of regime changes on the quality and quantity of water available for domestic municipal and industrial use, in the Outlet Lakes of the Nelson River. This study also attempts to project any resulting benefits, and the costs necessary to secure them, or the need for remedial measures.

BACKGROUND

Regulation of Lake Winnipeg is required to provide water storage for operation of the Nelson River hydroelectric power stations.

The regulation of Lake Winnipeg has involved the construction of new control works between Lake Winnipeg and Playgreen Lake and the construction of a power dam, at a site known as Jenpeg, which will control the release of water from Lake Winnipeg and the Outlet Lakes.

The Lake Winnipeg regulation may also involve a control structure on the East Channel of the Nelson River.

Historically the water levels on Lake Winnipeg and Playgreen Lake have fluctuated from 709 to 717 feet. Lake Winnipeg will be regulated between 711 and 715 feet.

NORWAY HOUSE

The Community of Norway House is located along an eight-mile stretch of the eastern shore of Little Playgreen Lake and the Jack River. The settlement includes Indian Reservation #17 and a non-treaty community. The settlement is spread along the shoreland with the major center of population on the Indian Reservation at Rossville. The population of the settlement is approximately 1800, of which 1588 are Treaty Indians.

The Jack River is a channel of water running from Playgreen Lake to the eastern shore of Little Playgreen Lake. The southern extremity of this river is approximately ten miles north-east of the outlet from the two-mile channel and fifteen miles north-west of Warren Landing.

The majority of the residents are located along the shoreline which serves as both a transportation route (winter and summer) and as the source of domestic water.

WATER SUPPLY

There are four major water and sewerage systems in the area, each operated independently. These systems service government agencies and do not directly supply the needs of the local inhabitants. The systems are:-

1) Dept. of Indian Affairs, Rossville - serving the Indian Agency Homes and the School. This system is totally within the Indian Reservation but does not directly service any of the residences of the local inhabitants. Water for domestic purposes may be hauled from hydrants strategically located on the water distribution system.
2) R.C.M.P. Complex, Fort Island - serving the R.C.M.P. personnel residences and the jail.
3) Indian Hospital Complex - operated by the Dept. of Indian Affairs, is located on Fort Island and serves the Hospital Complex and several Provincial Government Houses in the adjacent area.

4) Frontier School Division School - is located on Fort Island and services the school operated by the Provincial Department of Education which is known as the Jack River School.

These facilities, as noted above, are provided with a pressurized supply of chlorinated water.

The local geology precludes the use of wells for water, and local inhabitants secure their water supplies directly from the section of river or lake in proximity to their residences. This involves cutting holes in the ice during the winter time. A local health worker, in cooperation with the Department of National Health and Welfare and Northern Health Services of the Province, carries out an education program in the area with respect to water supplies, which is only partially successful in persuading the population to disinfect the water used for human consumption.

Although not thoroughly documented, there is reason to believe that water-borne diseases of bacterial and/or viral forms are endemic to many of the settlements. The files of Northern Health Services, Medical Services of National Health and Welfare, and Indian Affairs contain references to water-borne infections.

SEWAGE DISPOSAL

Each of the facilities noted above are served by sewage disposal systems. These systems are all "extended air" package treatment plants. Three of the four plants were erected in March of 1973. During an inspection tour, two of the plants appeared to be well operated but the third was suffering from start-up difficulties. Plant operation, a very basic necessity, appeared to be reasonably well in hand, and a training program to be undertaken in April of 1973 by the Federal Government should help the operators to improve their knowledge and effectiveness. Difficulty in maintaining adequate supplies of chlorine and the accumulation and removal of excess sludge were the only complaints voiced by the operators.

Operation of extended aeration plants is complicated by the lack of sludge handling facilities. Sludge accumulates in this type of plant, particularly in cold weather. Excess sludge has been removed from the hospital waste treatment plant by having a septic tank cleaning truck come from Winnipeg, at considerable expense. The sludge was hauled to the waste disposal grounds. Each plant should have sludge handling facilities in order to prevent sludge from reaching the receiving waters.

The discharge pipes of all the waste disposal systems are located upstream from water frontage of a large percentage of the residences of the community and as a result contribute to microbiological contamination of these waters. It is very important therefore that the waste treatment plants are well operated to lessen danger from water borne infections to the local residents who utilize the receiving waters directly for human consumption. In one instance, the sewage outfall is upstream of the related water intake structure.

The sewage treatment plants service only the government agencies and the general population are dependent upon privies. One report indicates that 90% of the homes have pit privies. There is little record of the condition of these privies, however, as the area is rock underlain, there is a shortage of topsoil for proper location of privies and seepage could, undoubtedly, be a major factor in the local water pollution problem.

There is no night soil collection system in the community.

SOLID WASTE DISPOSAL

No organized solid waste collection system is in operation in the area, although a waste disposal ground has recently been installed on Fort Island. This site is used by the government agencies and the hotel. The local inhabitants, however, do not use the facility due to lack of transportation and/or initiative. It is reported that local garbage disposal consists of backyard incineration or simply backyard accumulations. Undoubtedly, a goodly proportion of solid waste or the leachate from the waste finds its way into the water courses.

WATER QUALITY

The water quality of the surface waters meets most of the criteria for domestic water as proposed in the "Canadian Drinking Water Standards and Objectives, 1968". The notable exceptions are bacteriological quality, turbidity, and colour.

Bacteriologically the water quality is not so bad as to render it unfit for human consumption if properly disinfected. Bacteriological records indicate that most samples are positive for coliform organisms, including a reasonably high proportion which are positive for fecal coliform. Fecal coliforms would be indicative of local pollution sources such as sewer outfalls or leachate draining overland from the settlements.

The turbidity of water according to the "Canadian Drinking Water Standards and Objectives" show less than one as an objective and five as a maximum acceptable limit for public supplies. The levels of the local water range from a low of ten to a high of twenty, excluding the spring runoff period for which no records are available. The expectation would be that turbidity would be substantially higher in the spring.

The effect of this turbidity is not critical as it is generally accepted that turbidity has no harmful effects itself but that it may result in users seeking an alternate source that is clearer but more grossly contaminated.

Turbidity may provide harborage for bacteria with the result that some bacteria may survive disinfection processes. Survival would depend on the concentration of chlorine, the contact time, as well as the physical/microbiological condition of the water.

Colour in water samples on record ranges from a high of forty to a low of ten. The suggested drinking water standards places five as a maximum acceptable colour and less than five as desirable. Colour standards are based entirely on aesthetics.

The "Standards" would generally be interpreted as requirements for treated water and not for raw water supplies.

Any discussion of water quality should be qualified to the effect that results are based on samples which are generally collected from existing water intakes or the central portion of river or lake systems. Householders are faced with water withdrawals near the shoreline which would, in general, be subject to higher contaminant levels, including coliform bacteria,color and turbidity.

FLOW REGIME

There is no data available which records the velocity of flows in the Norway House area and only two years of flow records in the East Channel (1969, 1970) of the Nelson River.

The flow in the East Channel varied from 9,650 to 23,600 cfs. This flow would not all pass through the Jack River and, therefore, no indication of water flow patterns in the community can be deduced.

DISCUSSION OF THE EFFECTS OF LAKE REGULATION

The regulation of Lake Winnipeg should not affect the chemical quality of the waters at Norway House.

Water level fluctuations in the Norway House area will be reduced. This reduction of water level fluctuation will better facilitate the withdrawal of water for domestic use.

The effect of the use of the lake as a portion of a reservoir may have an adverse effect as the likelihood of the water levels dropping in the winter months are slightly increased. A significant drop in the water level during any one year could mean that some water holes may dry up, necessitating selection of a new hole some distance further from the shoreline. This is a situation which has undoubtedly occurred before.

The effect of damming the East Channel of the Nelson River to divert the flow of water to the Jenpeg power site could, however, have a fairly major impact on the physical/microbiological quality at Norway House. Dependent on flow regulation, such a control structure could reduce the movement of waters past the community resulting in reduced dilution of wastes both from point sources and land drainage. Dilution under these circumstances would be primarily attributed to lake currents. This could seriously affect the quality of water used for domestic purposes.

In conclusion, it could be stated that the current practices of water supply and waste disposal in the area are less than desirable. These conditions will persist regardless of measures taken by Manitoba Hydro unless unsatisfactory local sanitation practices are upgraded by appropriate agencies. Such remedial measures could include the provision of a home water delivery service from an approved source.

RECOMMENDATIONS

1) That the effect on flow in the area of Norway House should be carefully examined by the Manitoba Hydro prior to the construction of any

control works on the East Channel. Reduced flows attributed to the Manitoba Hydro project may have a significant and detrimental effect on dilution processes associated with domestic waste disposal in this area.

2) That water movement measurements be made along the Jack River, i.e. velocity readings. Such measurements would be used to determine minimum future flow requirements for dilution.

TABLE 1 EAST CHANNEL - NATURAL FLOW CONDITIONS

AVERAGE FLOW FLUCTUATIONS IN PERCENT

RANGE IN CFS x 1000	January		February		March		April		May		June		July		August		September		October		November		December	
	Rise	Drop	Rise	Drop	Rise	Drop	Rise	Drop	Rise	Drop	Rise	Drop	Rise	Drop	Rise	Drop	Rise	Drop	Rise	Drop	Rise	Drop	Rise	Drop
0 - 1	21	0	47	50	29	47	29	16	0	0	5	21	32	21	13	21	3	13	3	21	8	0	29	13
1 - 2	16	34	0	3	0	21	18	5	3	0	11	16	16	5	11	29	8	53	3	42	0	0	34	13
2 - 4	3	24	0	0	0	3	5	0	13	0	18	26	26	0	18	8	0	24	0	32	0	5	11	0
4 - 6	3	0	0	0	0	0	26	0	18	0	3	0	0	0	0	0	0	0	0	0	0	42	0	0
6 - 8	0	0	0	0	0	0	0	0	26	0	0	0	0	0	0	0	0	0	0	0	0	45	0	0
8 -	0	0	0	0	0	0	0	0	39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

MEAN MONTHLY FLOWS IN CFS.

	January	February	March	April	May	June	July	August	September	October	November	December
MINIMUM	0	0	0	0	1,800	4,200	3,200	1,000	0	0	0	0
AVERAGE	8,142	8,042	7,534	9,174	15,850	15,511	16,442	16,434	15,092	13,721	8,224	8,832
MAXIMUM	19,500	19,200	17,800	17,100	25,600	28,100	28,700	27,100	24,200	22,800	18,700	17,700

TABLE 2 EAST CHANNEL - REGULATED FLOW CONDITIONS

AVERAGE FLOW FLUCTUATIONS IN PERCENT

RANGE IN CFS x 1000	January		February		March		April		May		June		July		August		September		October		November		December	
	Rise	Drop	Rise	Drop	Rise	Drop	Rise	Drop	Rise	Drop	Rise	Drop	Rise	Drop	Rise	Drop	Rise	Drop	Rise	Drop	Rise	Drop	Rise	Drop
0 - 1	6	50	43	51	9	16	34	18	0	0	28	17	38	17	42	18	37	34	33	41	3	0	10	16
1 - 2	0	37	4	1	2	24	28	10	0	0	24	6	24	4	25	4	9	14	1	18	0	0	16	22
2 - 4	0	7	1	0	0	49	10	0	1	0	21	3	14	1	10	1	1	5	0	6	0	10	4	32
4 - 6	0	0	0	0	0	0	0	0	24	0	1	0	2	0	0	0	0	0	0	1	0	47	0	0
6 - 8	0	0	0	0	0	0	0	0	52	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0
8 -	0	0	0	0	0	0	0	0	23	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0

MEAN MONTHLY FLOWS IN CFS.

	January	February	March	April	May	June	July	August	September	October	November	December
MINIMUM	700	1,300	1,400	2,400	7,800	7,700	8,900	8,100	6,100	5,300	1,000	2,800
AVERAGE	10,890	10,876	9,321	9,922	16,825	17,646	18,452	19,111	18,921	18,422	12,712	11,836
MAXIMUM	16,900	17,000	15,600	15,200	23,800	24,600	24,100	23,000	22,800	22,700	18,000	17,500

Reference: "Water Level Information Lake Winnipeg and Outlet Lakes", December 72

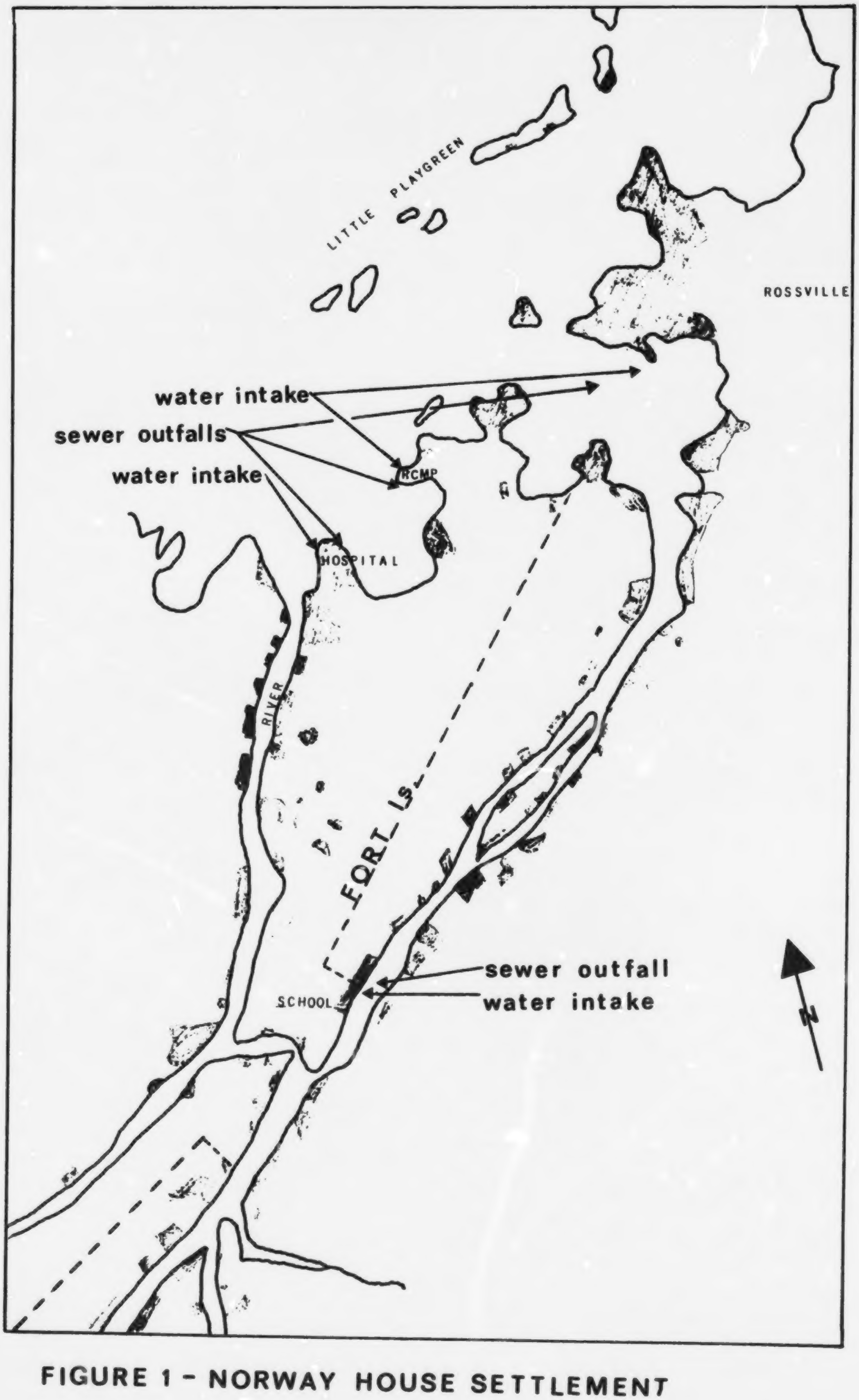
LITTLE PLAYGREEN
ROSSVILLE
water intake
sewer outfalls
water intake
RCMP
HOSPITAL
RIVER
FORT IS.
sewer outfall
water intake
SCHOOL
N

FIGURE 1 - NORWAY HOUSE SETTLEMENT

CROSS LAKE

The community of Cross Lake is located on a lake which is part of the Nelson River system and from which the community derives its name. Part of the community is located on Cross Island. Cross Lake Community is located such as to be influenced by flows from the East Channel of the Nelson River. The community, which comprises the Cross Lake Indian Reserve #19, is a settlement that stretches over a distance of five miles along the shoreline. A foot bridge spanning the water near the southern end of the community is the only man-made crossing serving the island. The population of the Indian Reservation is 1,471. The non-Indian population is limited to personnel attached to government agencies such as teachers, health workers, and Hudson's Bay Company Employees.

WATER SUPPLY

There are three major water intake structures in the community, two of which are related to schools and one with the Nursing Station. The old school structure at the extreme southern end of the community is being continued in partial use to service a day-care centre, although the school itself was destroyed by fire in 1970. During a site visit in March, 1973, chlorination of the water at the day-care centre did not appear to be the practice. A freezing problem was also being experienced with the water system.

The new school structure, located near the northern limit of population on Cross Island, has a water intake located in the main channel between the island and the mainland. This intake line, although laid under Federal Government supervision within the past two years was not constructed with a plan registering its exact location or depth. The line apparently enters the lake in a trench shared with the sewage outfall but branching upstream from the outfall at some undefined point. The water intake is downstream from the populated area. At the time of inspection of the system in March, 1973, the chlorination system was not functioning and the chlorinator intended for the system had never been installed.

A site visit was not made to the Nursing Station. It was noted in passing that the water system was being restored (the system had been frozen).

The majority of the population of the community depends upon surface water for domestic purposes although some shallow wells exist on the mainland. Geological conditions will not permit construction of wells on Cross Island. Apparently no water delivery service is available to the community.

SEWAGE DISPOSAL

The population at large are dependent upon privies for sewage disposal. The old school site is serviced by a septic tank which discharges to the lake, upstream from the major portion of the community. At the time of the visit to the community, the sewer outfall line was frozen and the sewage was being pumped to the lake periodically with no evidence of chlorination being practised. The system is greatly reduced in volume since the school has not been replaced and the only usage of the outfall line is by a day-care centre located in temporary buildings.

A septic tank/soil absorption system services the Nursing Station with sewage disposal.

The new school complex is served by an extended aeration plant which appears, at least visually, to be operated in a satisfactory manner. The outfall from this plant is laid in the same trench as the water intake but branches downstream before its point of final discharge. Records of the exact location, depths etc. of the outfall are not available.

The operators of the sewage plant will be given additional training at a course in Norway House in late April 1973.

SOLID WASTE DISPOSAL

There is no established waste disposal ground in the community. As in Norway House most solid waste disposal is accomplished by incineration or deposition on the ground in the vicinity of the homes. Disposal sites would be required on both the island and the mainland to correct this situation. A collection system would also be required as there is a lack of transport in the area.

WATER QUALITY

Review of the water analysis available indicates that the flow past, (or through) the community is Nelson River water with no dilution from the major area of the lake. The quality with respect to chemical content is good, meeting most of the requirements of the "Canadian Drinking Water Standards" - 1968. Water quality does not meet the standards for the physical parameters, turbidity and colour. The presence of turbidity above the level of the Canadian Drinking Water Standards not only contributes to aesthetic displeasure, but also lessens the effectiveness of a disinfection program.

Bacteriologically, the water is unsafe for human consumption without prior treatment. This is confirmed from records which show that 61 of 63 samples collected for bacteriological purposes were positive for coliform organisms. Appropriate manual disinfection or continuous chlorination can render the water safe for human consumption.

Epidemiologically, the situation can be exemplified by reference to a memorandum from Mr. H. Wilson, Public Health Inspector, to Dr. N. S. Stephansson, Medical Director, (dated October 2, 1970). (Appended to this report). During a seven month period in 1970, from 1.1 to 4.4% of the population (on a monthly basis) had reported gastroenteric infections.

One of the major Health Education thrusts in northern settlements is to convince residents of the necessity to disinfect water supplies. There is reasonably good certainty that the success of this program can be correlated with disease case loads, particularly of the gastroenteric type.

FLOW REGIME

There are no records available that indicate the velocity of flow in the channel separating the community. There is a reported velocity but it is not sufficient to prevent the formation of an ice cover.

Considering the "Report on the Effects of Hydraulic Dredge Disposal on Upper and Lower Ospwagen Lake" and the intermediate position of Kiskittogisu between the community of Cross Lake and the 8-mile channel, it is unlikely that any effect will be felt by the community resulting from the dredging. When the channel is first opened there may be an increase in suspended solids past the community for a short period of time. It is difficult to envision anything more than a temporary surge in suspended solids.

The water level records and projections indicated that fluctuating water levels may be more of a problem at Cross Lake than any other aspect of the Lake Winnipeg Regulation. The records show a maximum fluctuation of just over 10 feet for the period of records. Projections show that the fluctuation could increase by three feet to a maximum range of 13 feet in the future.

Severe fluctuations in water level could affect both water withdrawals and near-shore water quality. In the winter, water obtained from holes in the ice could dry up, necessitating a re-location of the hole to some point closer to the main channel during periods of draw down. In open water periods, docks used to gain access to the water may be flooded under conditions of high water or become land based under low water conditions.

The fluctuating water levels may increase shoreline erosion and could appreciably increase the turbidity of the water available to the Cross Lake Community.

CONCLUSIONS

1. The surface water at Cross Lake can be classified as bacterially contaminated in terms of its use as a domestic water supply. The contamination is of local origin and will continue unless remedial measures are taken by the appropriate agencies.
2. Increased turbidity associated with fluctuating water levels could decrease the effectiveness of water chlorination in rendering water potable.
3. Regulation of Lake Winnipeg is likely to have a permanent effect on water quality at Cross Lake resulting from:
    a) increased turbidity from erosion associated with increased water level fluctuations, and
    b) a reduction in the flow past the community resulting from the control structure in the East Channel, impeding dilution of discharged and surface borne wastes.

RECOMMENDATIONS

1. That flow and velocity data be collected from the channel separating the community so that future regulation can be controlled to ensure adequate dilution of discharged and surface borne wastes from the community.

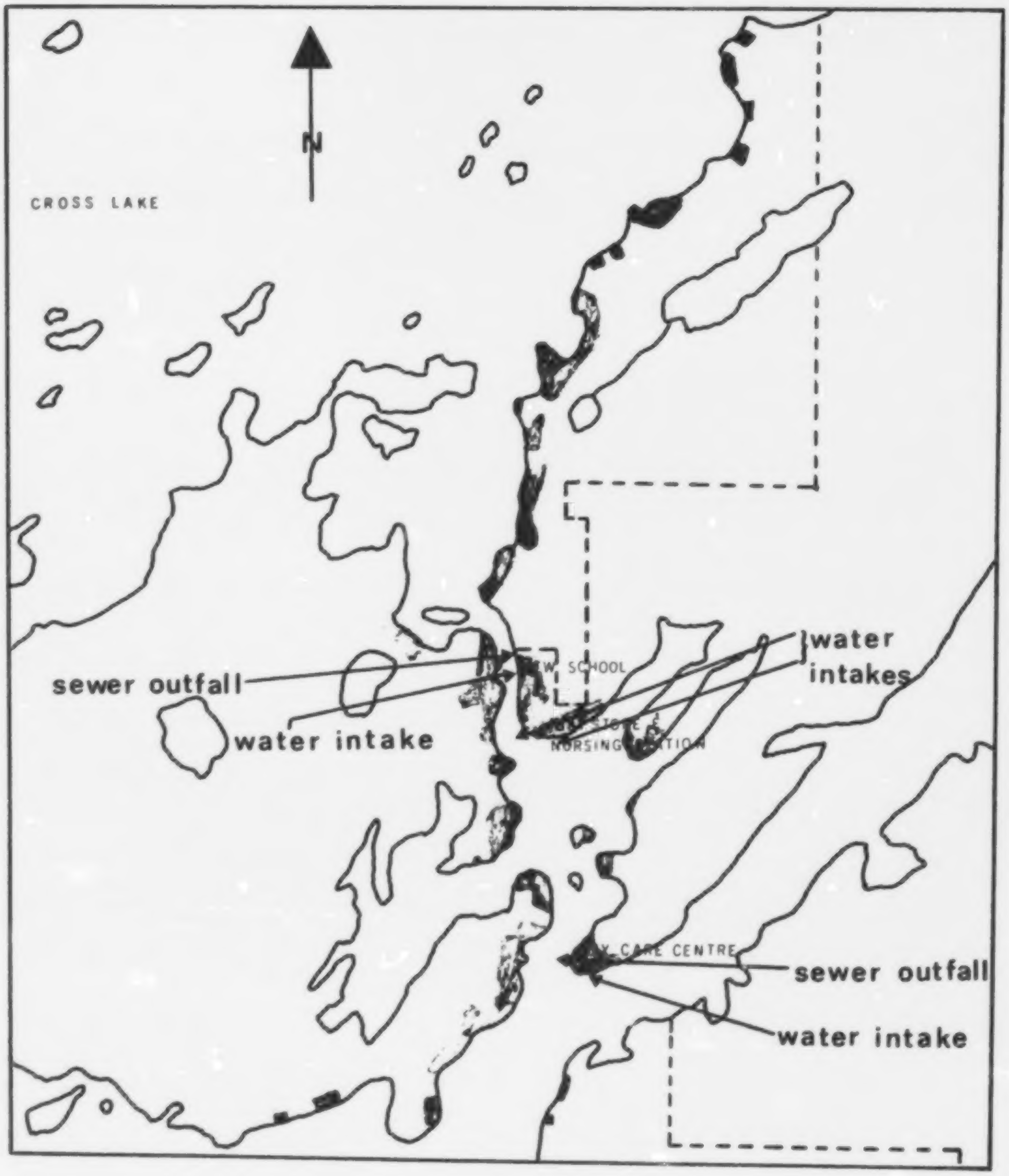
N
CROSS LAKE
W. SCHOOL
STORE &
NURSING STATION
CARE CENTRE
sewer outfall
water intake
water intakes
sewer outfall
water intake

FIGURE 2 - CROSS LAKE SETTLEMENT

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ANNEX 1

COPY

October 2, 1970

Mr. H. Wilson
Public Health Inspector
Northern Health Services

Dr. N. S. Stephansson
Medical Director
Northern Health Services

CROSS LAKE - POLLUTION

Further to Mr. W. C. McLean's memorandum of September 21, 1970, a visit was made to the above community on September 29, 1970. The following was noted and recorded:

Two sewer outfalls into Cross Lake from Department of Indian Affairs and Northern Development; one from school and the other from Teacher's residence. The sewer outfall is upstream from the majority of the population. This school (above) had a small chlorinator installed but was not working at the time of visit.

Nursing Station chlorinator not operating. Federal Health Inspector has been in the community and has taken bacteriological water samples and Biochemical oxygen demand tests. I also received information that the Federal Public Health Engineers would be in area shortly.

Contacts: Chief Walter Monias and Nurse-in-Charge

The Nurse-in-Charge was interviewed and the following information was obtained from her. There are approximately 1900 people in this community so the following percentages are probably attributed from the water supply (gastro-enteritis cases obtained from nurses' files):

No. of Cases	Month	Percentage of Population Affected
21	February	1.1% of population affected
30	March	1.6% of population affected
29	April	1.6% of population affected
42	May	2.2% of population affected
74	June	3.9% of population affected
52	July	2.7% of population affected
83	August	4.4% of population affected

These figures only show people that reported to Nursing Station so figures would be higher if all mild and unreported cases were shown.

The community is divided by Cross Lake with the majority of the population presiding on the East side of the Lake. The Department of Northern Affairs and Government of Canada have instructed roads for the East side. A bridge linking settlements is being presently constructed.

It was learned that the band is contemplating in the construction of a well for the West side, however, past tests on similar topography, such as Wabowden, revealed negative. This should be brought to the band's attention.

From this visit my recommendations are as follows:

1) Notify Clean Environment Commission.

2) Notify Department of Indian and Northern Development to chlorinate their sewage effluent and water.

3) Notify Federal Medical Services to chlorinate their water supply.

4) Notify band Council and Mayor and Councils that water is unfit for human consumption and to consider either water delivery or by chlorinated water stand pipes (building and heated).

5) Our engineers contact Federal authorities re proposed survey and present activities on same.

Signed

H. Wilson
Public Health Inspector

HW/ljh

Annex 2

COPY

CROSS LAKE BAND OF INDIANS
CROSS LAKE, MANITOBA

September 9, 1970

File/K-7

R. H. Connelly
Regional Director - Manitoba
Department of Indian Affairs
& Northern Development
301-267 Edmonton Street
WINNIPEG 1, Manitoba

Dear Mr. Connelly:

We have a very serious trouble concerning our drinking water from the lake.

The sanitation problem we have which involves is that the Federal Junior High School has a sewage system that drains directly into the waters of the Cross Lake settlement. The High School, as you know, is located at the upper end of the Reserve and the water runs from there through the whole settlement. Water samples have been taken by the Nursing Station staff and the two Health Workers on August 11, 1970 and was discovered that the Coliform count by the school is 1500 + 100 mls of water. The rest of the settlement ranges from 23 to 150 coliforms per water and that is as far as 4 to 5 miles away.

We want your Department in conjunction with the Health Department to look into this matter immediately. This could mean the closing down of the Junior High School sewage system if no immediate action is taken by both Departments.

We think, along with the Health Nurses that the only way to avoid water pollution in the Cross Lake community would be to have water wells constructed throughout the community. The Junior High School building should have a cesspool constructed inland instead of dumping the sewage into our drinking water.

Yours truly,

Chief, Walter Monias

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RENEWABLE RESOURCES,
THE PAS, MAN.

WM/vs.

APPENDIX 4 - J

WATER SUPPLY AND SEWAGE DISPOSAL FACILITIES OF LEAF RAPIDS, SOUTH INDIAN LAKE AND NELSON HOUSE

WATER SUPPLY AND SEWAGE DISPOSAL FACILITIES
OF
LEAF RAPIDS, SOUTH INDIAN LAKE AND NELSON HOUSE

by

J. N. WARRENER
Environmental Management Division
Manitoba Department of Mines, Resources and Environmental Management
Winnipeg, Manitoba
March, 1975

for

THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SPECIAL NOTE

THE CONCLUSIONS AND RECOMMENDATIONS CONTAINED IN THIS APPENDIX ARE THOSE OF THE AUTHOR(S) AND ARE NOT NECESSARILY THE SAME AS THE CONCLUSIONS AND RECOMMENDATIONS OF THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD AS EXPRESSED IN THE SUMMARY REPORT AND THE TECHNICAL REPORT.

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Nelson House . . . . Page 9
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FIGURE

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COMMUNITY WATER SUPPLY, LEAF RAPIDS, SOUTH INDIAN LAKE AND NELSON HOUSE

INTRODUCTION

This document was prepared for the Lake Winnipeg, Churchill and Nelson Rivers Study Board.

OBJECTIVES

The objective of this community water supply study is to determine how the Churchill River Diversion project may affect the quality and quantity of water available for domestic and other uses at the townsite of Leaf Rapids, the industrial site at Ruttan Lake and the communities of South Indian Lake and Nelson House. The study had the following specific objectives:

1. To assess changes in the physical and chemical characteristics of the water at Leaf Rapids (and also the associated industrial site at Ruttan Lake);
2. To assess the effect of water level changes on the water intake and sewage outfall structure at Leaf Rapids (and associated industrial site at Ruttan Lake);
3. To assess the effect of increased flows and higher water levels at the South Indian Lake settlement in terms of both water supply and waste water disposal; and,
4. To assess the effect of increased flows and higher water levels at the Nelson House settlement in terms of both water supply and waste water disposal.

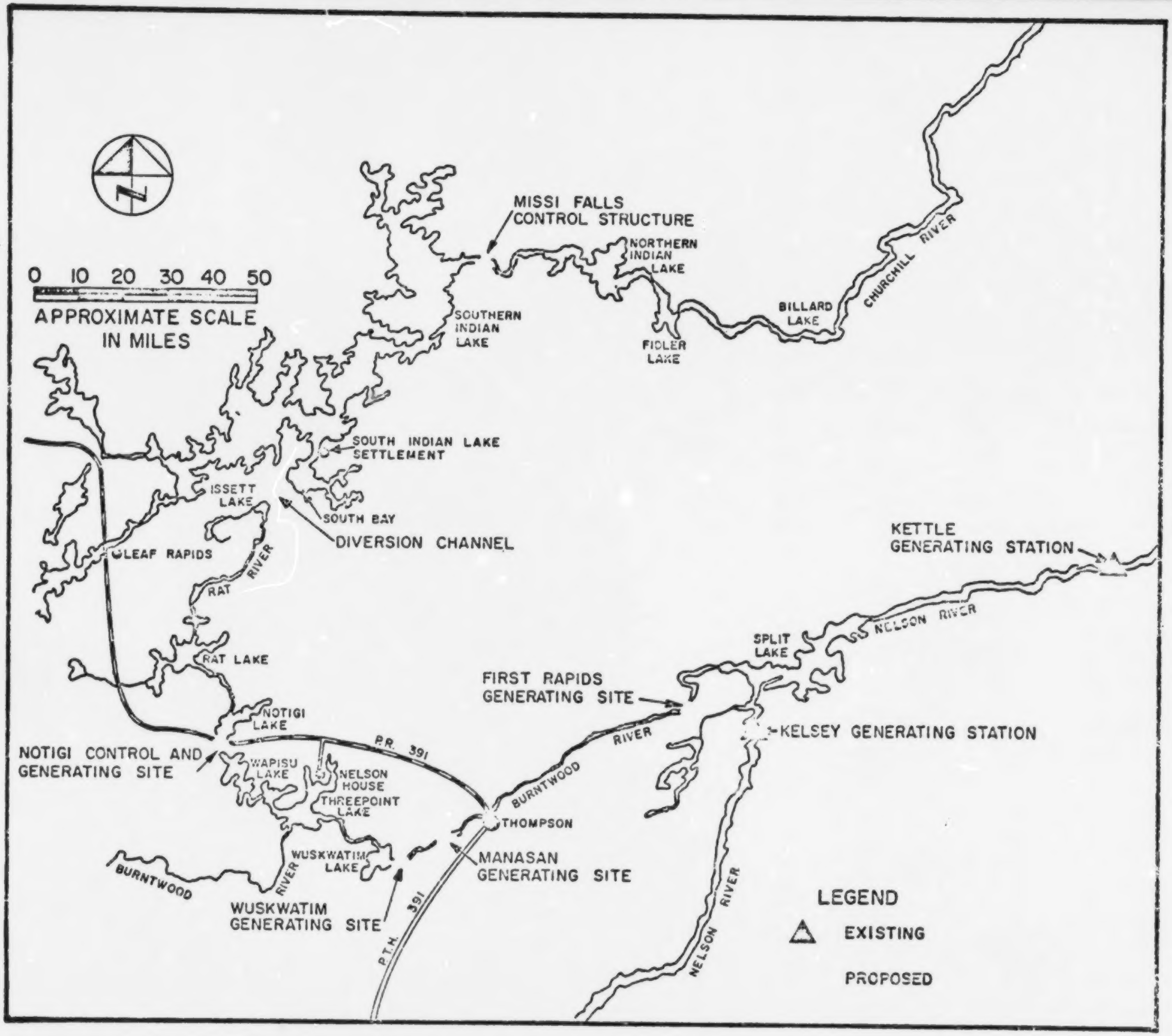
0 10 20 30 40 50
APPROXIMATE SCALE IN MILES
N
MISSI FALLS CONTROL STRUCTURE
NORTHERN INDIAN LAKE
SOUTHERN INDIAN LAKE
FIDLER LAKE
BILLARD LAKE
CHURCHILL RIVER
SOUTH INDIAN LAKE SETTLEMENT
ISSETT LAKE
SOUTH BAY
DIVERSION CHANNEL
LEAF RAPIDS
RAT RIVER
RAT LAKE
KETTLE GENERATING STATION
NELSON RIVER
SPLIT LAKE
FIRST RAPIDS GENERATING SITE
KELSEY GENERATING STATION
NOTIGI LAKE
NOTIGI CONTROL AND GENERATING SITE
P.R. 391
WAPISU LAKE
NELSON HOUSE
THREEPOINT LAKE
BURNTWOOD RIVER
THOMPSON
WUSKWATIM LAKE
MANASAN GENERATING SITE
BURNTWOOD
RIVER
WUSKWATIM GENERATING SITE
P.T.H. 391
NELSON RIVER
LEGEND
△ EXISTING
PROPOSED

FIGURE 1 CHURCHILL RIVER DIVERSION.

BACKGROUND

The Churchill River Diversion project includes raising the water level on Southern Indian Lake to elevation 847 feet and diverting up to 30,000 cfs from the Churchill River into the Nelson River via the Rat-Burntwood river system. This project may affect water supply to the townsite at Leaf Rapids and the settlements at South Indian Lake and Nelson House.

At Leaf Rapids, the level of the Churchill River will be raised approximately nine feet. At the South Indian Lake settlement, the water elevation of Southern Indian Lake will be raised approximately 10 feet on average and the velocity of the water passing the community will also be increased. At Nelson House, the water level of Footprint Lake will be increased above its average level by perhaps as much as 25 feet under severe winter conditions.

This report was prepared from data made available by Manitoba Hydro, the Department of Indian and Northern Affairs, the Engineering Consultant firms of W. L. Wardrop and Associates and Underwood McLellan and Associates, and the Water Resources Division and the Environmental Management Division of the Department of Mines, Resources and Environmental Management.

This study examines the effects that diversion of the Churchill River into the Rat-Burntwood River system and regulation of Southern Indian Lake will have on existing community water supply and drainage systems in the townsite of Leaf Rapids (including the industrial site of Ruttan Lake) and the settlements of South Indian Lake and Nelson House.

This report was prepared by J. N. Warrener, P. Eng., Environmental Engineer with the Environmental Management Division of the Department of Mines, Resources and Environmental Management.

LEAF RAPIDS & RUTTAN LAKE

Leaf Rapids is a townsite established by the Manitoba Government located at the intersection of Provincial Road 391 and the Ruttan Mine Road. Population of the townsite at present is approximately 2400.

Ruttan Lake is an industrial site located some 10 to 15 miles east of Leaf Rapids. Ruttan Lake is the site of a mining operation of the Sherritt-Gordon Mines Limited.

WATER SUPPLY

The water supply source for the townsite of Leaf Rapids is the Churchill River. The water intake is located in the Churchill River approximately one half mile west of the townsite. Water is drawn by gravity from the river to a pumphouse. The water is chlorinated, heated and pumped to the distribution system of the townsite.

The industrial water supply source for the operation at Ruttan Lake is either Rusty or Ted Lakes. The domestic water supply is drawn from Ted Lake.

WASTE DISPOSAL

Leaf Rapids sewage is collected by gravity and discharged to a waste disposal plant consisting of secondary sewage treatment. The plant effluent is discharged to an outfall ditch connected to a natural drain tributary to the Churchill River in the vicinity of Leaf Rapids.

Wastes of both sanitary and industrial origin associated with the Ruttan Lake mining operation are returned to Ruttan Lake. Ruttan discharges to Rusty Lake and hence to the Churchill River.

CONCLUSIONS

1. The water intake and pumphouse structures at Leaf Rapids should be unaffected by the proposed regulation and diversion of the Churchill River.
2. Water quality at the Leaf Rapids water intake site should remain unchanged.
3. The waste treatment plant and outfall pipe at Leaf Rapids should be unaffected by the proposed regulation and diversion of the Churchill River.
4. The drain tributary to the Churchill River into which Leaf Rapids townsite sewage effluent enters will following regulation and diversion of the Churchill River have an increased elevation. This will affect the dilution/dispersion characteristics of the effluent at the point where it reaches the Churchill River. This may have some significance dependent on the use to which this reach of the Churchill River is to be placed.
5. The proposed regulation and diversion of the Churchill River should not affect the operation of the water and waste disposal systems at the Ruttan Lake operation.

SOUTH INDIAN LAKE

South Indian Lake settlement located on the Churchill River between Southern Indian Lake and South Bay has a population of approximately 600. The river bisects the settlement. Southern Indian Lake will be raised from a present average level of 837 feet to elevation 847 feet.

WATER SUPPLY

Groundwater is unavailable at the South Indian Lake Settlement and reliance is placed solely on Southern Indian Lake as a water supply source. By and large, residents draw water directly from the lake by manual means for human consumption;that is, water is withdrawn in a pail near the shoreline under open water conditions and through the ice in winter. The location of water withdrawal from the shoreline depends on the preference of the individual.

Results of water quality analyses indicates that the water from Southern Indian Lake has excellent physical, chemical, and microbiological characteristics apart from turbidity,(in season) particularily in the near shore waters. Local shoreline contamination, however, renders the water unacceptable as a domestic water supply without prior treatment. Like most northern settlements, health workers attempt to convince the residents of the need and desirability of disinfecting water preparatory to human consumption.

It is expected, that work will be completed shortly on a waterworks system which will service the school, nursing station, store and hall. Water for this purpose will be drawn from Southern Indian Lake. The plans for this facility include the provision of coagulation, sedimentation, filtration, and chlorination of the water supply. This type of facility can render a water supply physically and microbiologically acceptable for human consumption. The plans also indicate that this system will provide some of the residents with relatively easy access to treated water thus forgoing a requirement to withdraw untreated water directly from the River.

WASTE DISPOSAL

Wastes by and large of human origin (body discharge, food preparation wastes and sullage) are disposed onto or into the ground. Since the buildings are spread along the shorelines, and sanitary measures are often poor, wastes , either directly or indirectly, enter the water creating contamination near the shore.

A sewerage system is being constructed to service the school, nursing station, store and hall. This will consist of a Package Sewage Treatment Plant (secondary treatment with effluent chlorination) with the effluent being returned to the Churchill River.

CONCLUSIONS

It is expected that the proposed regulation and diversion of the Churchill River will result in an increase of turbidity at the location of the South Indian Lake Settlement. The effect may be severe at the outset, moderating as the banks stabilize. Residents who withdraw domestic water by manual means will find the water more aesthetically displeasing. Suspended materials in water also results in greater difficulty in rendering a water bacteriologically safe to drink. The operators of the community waterworks system will also have greater difficulty in treating a water that contains additional turbidity. It is expected, however, that the system designers were aware of the changes in the water quality regime and took appropriate measures to provide the proper equipment to cope with the expected increase in turbidity.

The increased flow past the settlement should, however, lessen the concerns from both local shoreline contamination as well as the effect of objectionable constituants in the treated sewage effluent from the complex.

RECOMMENDATIONS

Since the physical quality of the water will undoubtedly deteriorate, more especially during the initial stages of the Churchill River regulation and diversion, it is recommended that as many families as possible be served from the finished water source being developed for the community complex. This would include only those families within a reasonable distance of the water distribution system of the complex and located on the same side of the river. It should be assured that the balance of the residents who are required to withdraw water for human consumption directly from the river should be advised of the requirement to disinfect the water. The water will be less aesthetically pleasing due to the presence of suspended material, but if appropriate disinfection measures are taken it should be bacteriologically safe.

NELSON HOUSE

Nelson House located on the north shore of Footprint Lake is a settlement with a population between 1,200 and 1,300 residents. Churchill River diversion flows will result in a substantially higher water level at Nelson House ranging from 15 to 25 feet depending on downstream regulation on the Burntwood River.

WATER SUPPLY

Groundwater is unavailable at Nelson House Settlement and Footprint Lake is used exclusively as a water supply source. Residents withdraw water directly from the lake by manual means for all domestic purposes including human consumption.

Results of water quality analyses indicates that the water from Footprint Lake has good physical, chemical and microbiological characteristics apart from turbidity and algae growths in season. Local shoreline contamination however renders the water unacceptable as a domestic water supply without prior treatment. Like other northern settlements, health workers attempt to persuade the residents of the need and desirability of disinfecting water preparatory to human consumption.

A communal waterworks system to service the school complex was recently completed. A former water distribution system which had originally been intended to serve a part of the settlement with treated water from hydrants was also to be connected to the school water system. Water treatment consists of chlorination.

WASTE DISPOSAL

Wastes by and large of human origin are disposed onto or into the ground. Since most of the buildings are spread along the shoreline, and sanitary measures are often poor, wastes either directly or indirectly enter the water creating contamination particularily of a microbiological nature near the shore.

The school complex waste disposal system consists of a package type secondary sewage treatment plant with effluent chlorination. The effluent is returned to Footprint Lake.

CONCLUSIONS

The increase in lake level at Nelson House will result in an increase of turbidity with the possibility of a more severe effect at the outset. The turbidity should moderate as the shores stabilize. The water supply will be more aesthetically displeasing and disinfection may be hindered by the suspended particles.

The Churchill River regulation and diversion will result in changes to the chemical water quality in the Rat-Burntwood River system since 85 to 90 percent of the flow in this system will be composed of Churchill River water following diversion. The chemical change will not likely be evident to domestic users at Nelson House. Apart from this is the fact that Footprint Lake is not part of the main stem of the Rat-Burntwood River system and the water quality may continue to reflect the major contributing drain to Footprint Lake which is the Footprint River.

With the increased residence time in Footprint Lake there may be a greater tendency to algae growth which would render the water less acceptable as a water supply.

The heightened water level would provide more dilution for local contaminants but the increased residence time and consequent reduction in water movement towards the outlet would diminish the flushing action.

Little attention was paid to the effect of changes on the hydraulic regime associated with diversion as it related to the waterworks and sewerage system structures at the school since the design consultants were aware of the diversion project from the outset of the design thus enabling them to take appropriate measures to safeguard the systems against regime changes.

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APPENDIX 4 - K

WATER SUPPLY AND SEWAGE DISPOSAL FACILITIES OF CHURCHILL AND THOMPSON

WATER SUPPLY AND SEWAGE DISPOSAL FACILITIES
OF
CHURCHILL AND THOMPSON

by

A. B. SPARLING
Department of Civil Engineering
University of Manitoba
June, 1973

sub-contracted by:

ENVIRONMENTAL MANAGEMENT DIVISION
Department of Mines, Resources and Environmental Management

for

THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SPECIAL NOTE

THE CONCLUSIONS AND RECOMMENDATIONS CONTAINED IN THIS APPENDIX ARE THOSE OF THE AUTHOR(S) AND ARE NOT NECESSARILY THE SAME AS THE CONCLUSIONS AND RECOMMENDATIONS OF THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD AS EXPRESSED IN THE SUMMARY REPORT AND THE TECHNICAL REPORT.

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FIGURES

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COMMUNITY WATER SUPPLY, CHURCHILL AND THOMPSON

LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY

INTRODUCTION

This document was prepared for the Lake Winnipeg, Churchill and Nelson Rivers Study.

OBJECTIVES

The objective of this present study is to determine how the hydroelectric development of the Manitoba Hydro on the Churchill River and Nelson River may affect the quantity and quality of water available for domestic and other uses at the townsite and environs of Churchill and the City of Thompson. Specifically, the study had the following objectives;

1. To assess changes in the physical/chemical characteristics of the water associated with diversion of the Churchill River on users in the Churchill area.
2. To assess the effect of water level changes, associated with reduced flows on the lower Churchill River and on the water intake structures in the Churchill area.
3. To assess the effect of changes in the physical/chemical characteristics of the waters of the Rat-Burntwood River System resulting from the diversion of the Churchill River both in terms of diversion and diversion with impoundment on the main water treatment plant at Thompson, the Birchtree Mine and Pipe Lake Mine.
4. To assess the effect of water level changes on the following structures in the Thompson Area:

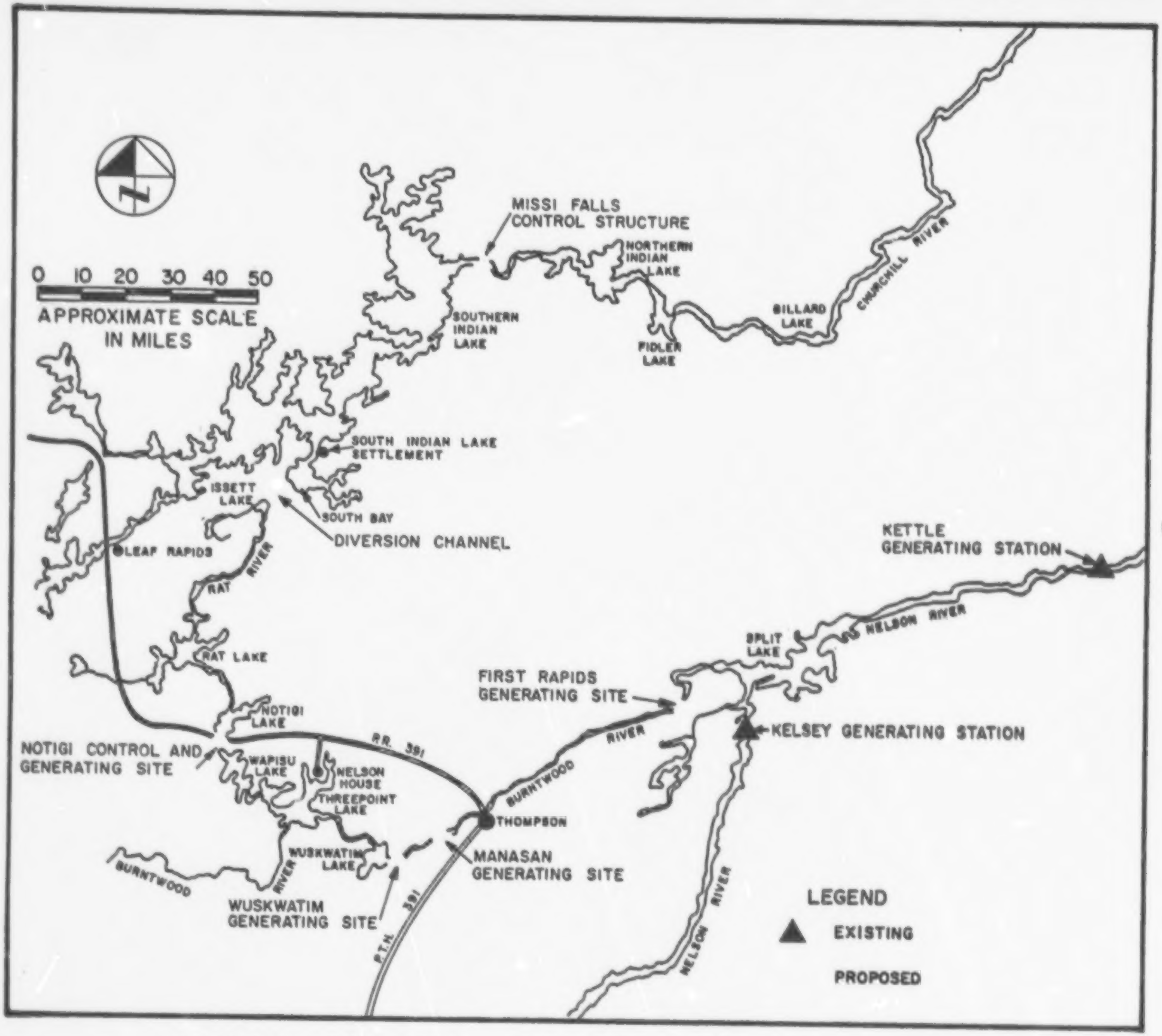
APPROXIMATE SCALE IN MILES
0 10 20 30 40 50
MISSI FALLS CONTROL STRUCTURE
NORTHERN INDIAN LAKE
SOUTHERN INDIAN LAKE
FIDLER LAKE
BILLARD LAKE
CHURCHILL RIVER
SOUTH INDIAN LAKE SETTLEMENT
ISSETT LAKE
SOUTH BAY
DIVERSION CHANNEL
LEAF RAPIDS
RAT RIVER
RAT LAKE
KETTLE GENERATING STATION
NELSON RIVER
SPLIT LAKE
FIRST RAPIDS GENERATING SITE
NOTIGI LAKE
NOTIGI CONTROL AND GENERATING SITE
P.R. 391
KELSEY GENERATING STATION
WAPISU LAKE
NELSON HOUSE
THREEPOINT LAKE
BURNTWOOD RIVER
THOMPSON
WUSKWATIM LAKE
MANASAN GENERATING SITE
BURNTWOOD
RIVER
WUSKWATIM GENERATING SITE
P.T.H. 391
NELSON RIVER
LEGEND
▲ EXISTING
PROPOSED

FIGURE 1 CHURCHILL RIVER DIVERSION.

i) The water pumping station serving the City of Thompson and the Main Mine Complex,

ii) The pumping stations at Birchtree and Pipe Lake Mines,

iii) The main sanitary sewer outfall and storm sewer outfalls of the City of Thompson,

iv) The drainage systems associated with the mining operations at the main plant site, Birchtree Mine and the Pipe Lake Mine.

BACKGROUND

The diversion of the Churchill River into the Rat-Burntwood River System as part of the program to develop maximum power in the Nelson River hydroelectric generating stations will affect both the townsite of Churchill and the City of Thompson.

At Churchill the flow of water past the water intake structure will be greatly reduced. At Thompson the flow of water will be increased by a factor of about 10. The resultant water quality at both locations will be different than that under natural conditions.

METHODOLOGY

This report was prepared from data made available by Manitoba Hydro, the Local Government District of Churchill, the City of Thompson, the International Nickel Company, the Environmental Protection Branch and the Water Resources Branch of the Department of Mines, Resources and Environmental Management and augmented by on-site visits to the areas including interviews with local people.

CHURCHILL

The Churchill Study area is confined to the Churchill townsite area, Camp Akudlik and Fort Churchill. These sites may be affected by changes in the flow regime of the Lower Churchill River (downstream from Missi Falls) as a result of the diversion of the Churchill River at Southern Indian Lake.

CONCLUSIONS

The changes in the flow regime of the Lower Churchill River, as a result of diversion of Southern Indian Lake at South Bay, will have the following consequences at Churchill, Manitoba:

1. Relocation of the water intake structure will be required for the protection from ice damage associated with reduced water levels resulting from reduced flows. Salt water intrusion from Hudsons Bay is not considered to be a problem in terms of water quality, if flow is above 2,000 c.f.s.
2. Minor changes in water quality will occur due to the greater impact of the tributaries of the Churchill River in its lower reaches. These changes will be confined to physical/chemical water quality parameters which will not affect public health. These changes initially will be identifiable to the users.
3. Waste disposal practices in the area will not be affected as waste discharges are all made into the area under tidal effect.
4. Difficulties that are currently encountered in maintaining the existing watermain from the intake pumphouse to the main pumphouse due to exterior corrosion associated with salt water intrusion will likely be intensified.

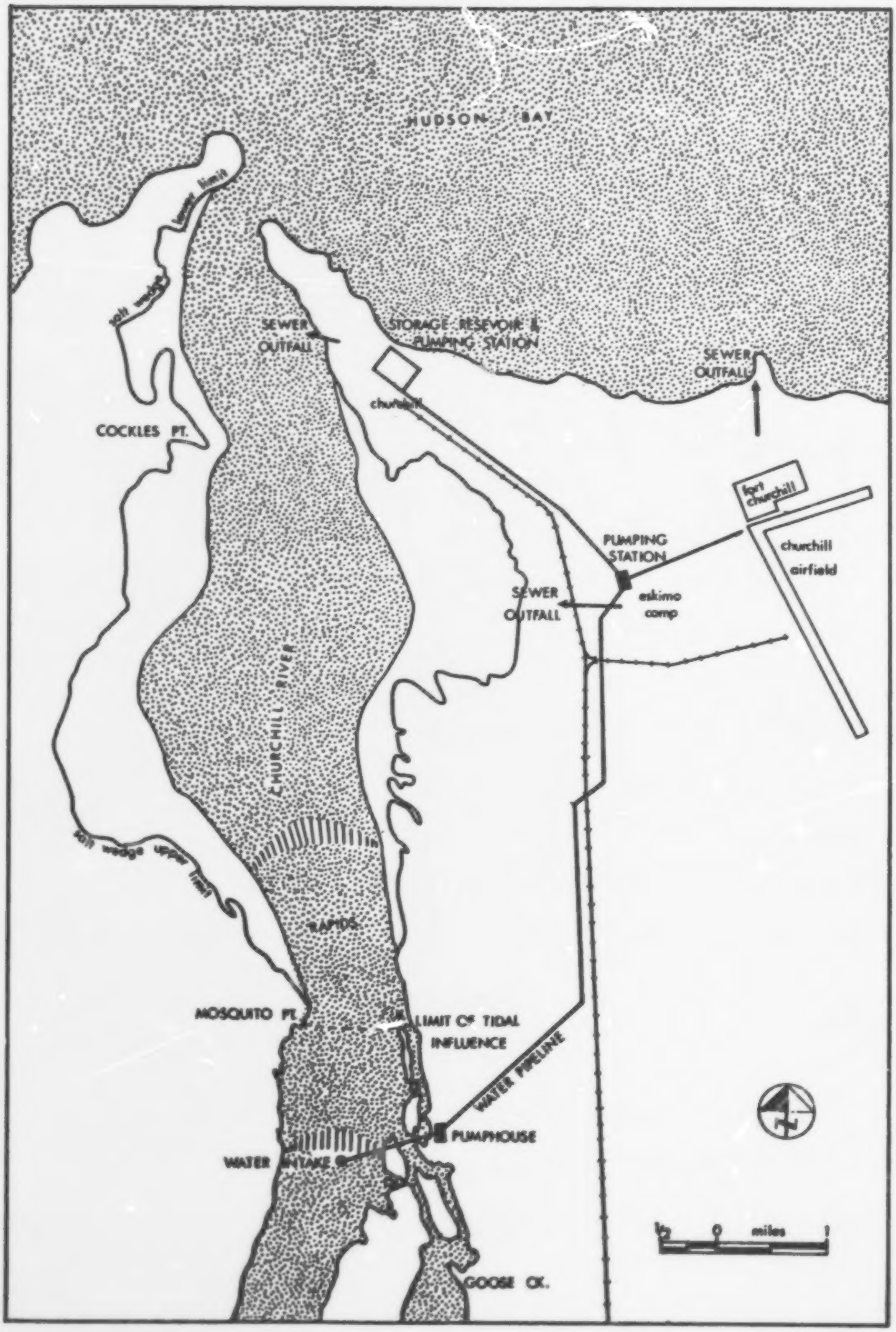
HUDSON BAY
salt wedge lower limit
SEWER OUTFALL
STORAGE RESEVOIR & PUMPING STATION
SEWER OUTFALL
churchill
COCKLES PT.
fort churchill
PUMPING STATION
churchill airfield
SEWER OUTFALL
eskimo camp
CHURCHILL RIVER
salt wedge upper limit
RAPIDS
MOSQUITO PT.
LIMIT OF TIDAL INFLUENCE
WATER PIPELINE
PUMPHOUSE
WATER INTAKE
GOOSE CK.
½ 0 miles 1

FIGURE 2 – CHURCHILL & DISTRICT

The material of construction of the pipeline is a coated aluminum which has failed at a number of locations due to aggressive soils and/or burial in brackish saline water.

WATER SUPPLY

The water for the Churchill area is supplied by a system operated by the Federal Department of Public Works. Treatment of the water is confined to chlorination although the Local Government District has installed facilities to add fluorine to the townsite water supply.

The intake structure is located on the Churchill River just upstream from a series of rapids, known as Goose Rapids, approximately 9 miles from Hudson Bay. A lengthy intake structure conveys the water to a pumphouse. The water is heated prior to being pumped to a reservoir at a location near the shore of the bay midway between the townsite and the fort. At the reservoir, the water is re-heated and re-pumped to the various users. The Local Government District has a pumphouse in the townsite area. The water is again heated, fluoride added and it is then pumped to the distribution system of the townsite.

DISCUSSION OF THE WATER INTAKE STRUCTURE

Historically the Churchill area was serviced by water obtained from Lake Isabel, a pot hole lake located adjacent to the camp. This supply became inadequate due to the size and nature of the drainage basin and increasing water use. In the early 1960's the source was changed to the present location on the Churchill River.

Surveys were carried out by the Public Health Engineering Division of the Department of National Health and Welfare to ensure that the proposed intake structure was upstream of salt water penetration in the river estuary (due to tidal currents).

In 1968 and 1969 Manitoba Hydro conducted surveys along the river to obtain data from which to forecast salt water penetration associated with diversion of Churchill River waters.

The results of these surveys were used to verify the applicability of an empirical formula used to predict the distribution of salt water penetration in estuaries. The formula (developed by Ketchum and reported in Sewage and Industrial Wastes, Vol. 23, No. 2, February 1951) was found to apply to existing conditions as verified by salinity test data, and was applied to future anticipated conditions. The conclusions of this application as reported by Mr. R. W. Coley, Hydraulic Studies Engineer, Systems Planning Division of Manitoba Hydro were as follows:

> "The above method (Ketchum's empirical formula) was utilized to calculate the freshwater - salt water interface for conditions which existed when salinity measurements were obtained in September, 1968. The analysis agreed with field measurements. Also the analysis indicated that, following the Churchill River diversion, for the most extreme case of salt water intrusion, namely a minimum river flow of 4,000 cfs at Churchill and a maximum instantaneous tidal range of 18.5' (difference between maximum instantaneous high tide and low tide), the salt water would extend about 8 miles upstream of the mouth of the estuary which is still about 4,200 feet downstream of the water intake. With an average daily discharge of 10,000 cfs and average tidal ranges of

> 10 feet (determined from 1966 tidal records), the salt water - fresh water boundary would be about 13,500 feet downstream of the intake."

The report concluded that "Backwater calculations indicated that, as a result of lower river stages with reduced discharge, the existing water intake will have to be adjusted, or relocated to a deeper section of the channel. This would ensure continuous operation of the intake and would provide better protection from ice damage".

The intake is currently located at elevation 7.5 feet (Geodetic Datum) and the projected stages of the river are between 8.25 feet and 9.5 feet for flows of 4,000 and 10,000 cfs. Damage to the intake structure due to ice formation and ice movement will occur unless it is relocated.

DISCUSSION OF WATER QUALITY

Metering of flow in the Lower Churchill River basin is limited to a single tributary. This meagre data has been used to extrapolate flows on a unit area basis. The limited data suggests a mean flow of 8,000 cfs, with a low flow of 2,000 cfs, and high flow of 25,000 cfs in the Churchill River at the intake location.

The water quality changes most likely to be noticed by the public are associated with color and hardness. In neither case will the increase be harmful to the user, however, it may at the outset prove to create public irritation.

Water of acceptable quality (however higher in color) will continue to be available to the users at Churchill, if a minimum flow of 2,000 cfs is maintained.

WASTE DISPOSAL

The townsite of Churchill is served by an extended aeration type sewage treatment plant which discharges chlorinated effluent to the Churchill River near the Harbor Board dock facilities. This plant went into operation in January 1973. The plant is well operated and appears to be functioning efficiently. The discharge from the plant occurs to the river in the tidal zone.

The proposed changes in the Churchill River regime will have no effect on the outfall structure nor will the dilution afforded the discharge be affected.

The Village of Akudlik is served by a sewage lagoon which discharges to the river in the tidal zone and should not be affected by changes in the river regime.

The Fort discharges raw sewage directly to the tidal flats of the bay several miles from the river mouth and will remain unaffected.

THOMPSON

This study area is confined to those areas associated with the International Nickel Company complex including the Birchtree Mine, the Pipe Lake Mine as well as the City of Thompson.

The City of Thompson, with a population of 20,000 is located along the Burntwood River five miles downstream from Manasan Falls. (Figure 3). The city was started by, and is dependent upon the International Nickel Company's mining, smelting and refining complex located in the area. In addition to the main mine adjacent to the city, the company operates two other mines in the Burntwood River drainage basin. The Birchtree Mine is located about 5 miles from Thompson and Pipe Lake Mine about 20 miles from the city.

CONCLUSION

The diversion of Churchill River waters into the Rat-Burntwood River System will have the following effects at Thompson:

1. Chemical requirements of the water treatment plant will vary over a period of years as a result of lower color in the Churchill River water and as the effects of initial scour and projected storage reservoirs modify the suspended solids level. This will result in fluctuations in the cost of treating water.
2. Changes in dissolved and suspended solids in the raw water will affect the industrial use by the International Nickel Company.
3. The pumphouses for both the City of Thompson and the Birchtree Mine will have to be raised to ensure continuous water supplies and safety of operation.

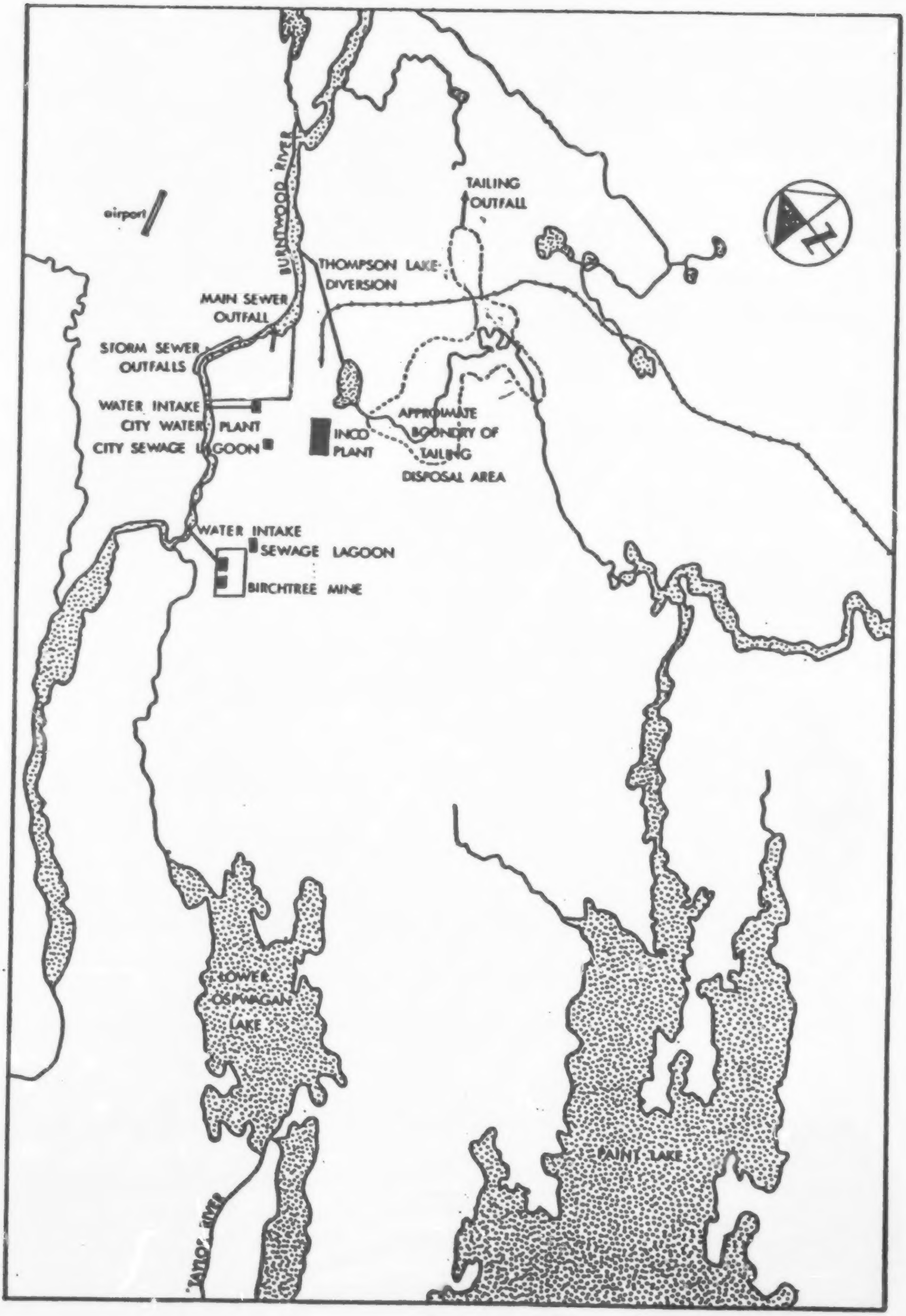
TAILING
OUTFALL
airport
BURNTWOOD RIVER
THOMPSON LAKE
DIVERSION
MAIN SEWER
OUTFALL
STORM SEWER
OUTFALLS
WATER INTAKE
CITY WATER PLANT
CITY SEWAGE LAGOON
INCO
PLANT
APPROXIMATE
BOUNDARY OF
TAILING
DISPOSAL AREA
WATER INTAKE
SEWAGE LAGOON
BIRCHTREE MINE
N
LOWER
OSPWAGAN
LAKE
TAYLOR RIVER
PAINT LAKE

FIGURE 3 – THOMPSON & DISTRICT

4. There is a possibility that ice jams on the Taylor River coupled with an increased water level resulting from backup of the Burntwood River could cause flooding of the Pipe Lake Mine pumphouse.
5. The discharge of process and sanitary wastes from the Inco complex will not be materially affected.
6. A new outlet structure for the main sewage treatment plant outfall of the City of Thompson will be required to protect the structure from the effects of increased and fluctuating water levels.

BACKGROUND

Prior to the start-up of the mining activity at Thompson, the drainage from Thompson Lake was south easterly into the Grass River via Thompson Creek. The development of a mine shaft adjacent to Thompson Lake led to the construction of a drainage channel to the Burntwood River downstream from the city. This drainage channel lowered the water level of Thompson Lake and protected the mine from flooding. Thompson Lake tributary drainage includes the main mine site and also a portion of the City of Thompson. This drainage was thus diverted from the Grass River system into the Burntwood River. An aerated lagoon system operated by the city for sewage treatment of waste from the westerly portion of the city lies within this area and discharges to the Thompson Lake tributary drainage basin. Birchtree Mine, five miles to the west of the main mine is adjacent to this area and all sewage and mine waters are pumped into a creek which is tributary to Thompson Lake. The sanitary sewage from the main mine complex as well as several process sewers also drain into Thompson Lake.

An area downstream from Thompson Lake (along Thompson Creek) was designated for tailings disposal a number of years ago. Under natural conditions the area drained into the Grass River, however, a dam was subsequently constructed to divert the overflow from the tailings pond into the Burntwood River, thereby protecting the Grass River from pollution arising from the mining complex.

A conclusion of the Rat-Burntwood Mitigation Study "Report on Sediment Transport Estimates" October, 1973 reads as follows:

> "4) Estimates of the concentrations resulting from the increased flows following diversion show that the major sediment contributions will be from the incoming flows and from channel erosion. The estimated average concentration at Thompson is 150 mg/l for flows of 40,000 cfs. The range of concentrations may be from small values (20 mg/l) to 400 mg/l as the channel changes will not take place at a uniform rate."

WATER SUPPLY

The City of Thompson and the Thompson Mine complex are supplied with water from a treatment plant and pumping station located in the northwest portion of the city. The pumphouse has a maximum pumping capacity of 48,000 gpm however it operates at an average rate of 30,500 gpm. The water treatment plant produces an average of 3,400 gpm which is approximately 50% of the treatment plant capacity. The remaining 27,100 gpm pumped is used as untreated process water by the company.

The changes in the water elevation at Thompson are projected to raise the water level to elevation 618 feet (Geodetic) from approximately

604 feet (Geodetic). This increase in water level will affect the pumphouses supplying both Thompson mine and Birchtree mine. The pumphouse floor at Thompson is at elevation 618 feet (Geodetic Datum).

The projected water levels are for open water and it is therefore probable that winter ice levels will be higher. The possibility of higher waters resulting from ice jams is distinct. The result of projected higher water levels will require that the pump floor be raised to ensure safety and continuous water pumpage.

In treating the water, lime is added to provide alkalinity for the alum coagulation process, as the Burntwood River is deficient in alkalinity for this purpose. The Churchill River water has a lower alkalinity than the Burntwood River. The alkalinity of the Burntwood River at Thompson ranges from 60 to 75 mg/l as $CaCO_3$ over the period of record. The Churchill River at Southern Indian Lake and upstream ranges from 30 to 45 mg/l as $CaCO_3$ in terms of alkalinity. The Churchill River water will be the dominant factor at Thompson once diversion has taken place. (in a ratio of approximately 10 to 1)

Aluminum sulphate, a coagulant is used to reduce both suspended solids and color. It is a virtual impossibility to estimate alum requirements for coagulating water. Jar testing, using the water under consideration, is the only means of estimation of chemical requirements. The average dosage (annual) of alum in the past has been 100 mg/l. Since, however, the average suspended solids load is expected to materially increase, the alum requirements may also be expected to increase.

Industrial water use at the Thompson mine is largely untreated at the present time. This flow totals 27,100 g.p.m. Changes in the water quality may create problems with this supply. Suspended organic material and clay in the water adversely affect the flotation process in the mill, reducing the percentage of metal recovered and the purity of the recovered metal. Detrimental effects will also be felt in the refinery, specifically in the electrolyte make-up water. The result of these detrimental effects could be an increase in the required volume of treated water at the plant. In order to accurately assess the problem, tests would have to be conducted to determine the effects and any increased production costs in the flotation and refining processes.

Increases in total dissolved and or suspended solids will affect the water used for boiler water in any process and in the water used in the compressor building.

BIRCHTREE MINE

The Birchtree Mine water supply is pumped to the mine from a pumphouse located almost directly across the river from Manasan Falls. This water is chlorinated before domestic use. Increased dissolved and suspended solids will interfere with boiler feed water and may require treatment.

The pumphouse floor is at elevation 619 feet (Geodetic) and the increased water levels will require the pumphouse to be raised for safety and to ensure continuous operation.

PIPE LAKE MINE

The Pipe Lake Mine although several miles upstream from the Burntwood River is on the Taylor River which is tributary to Ospwagan Lake. The level of Ospwagan Lake near the mouth of the Taylor River on July 25, 1973 was 616.45 feet (Geodetic Datum). As this is upstream of Thompson the 618 foot level at Thompson will be reflected in an elevation greater than 618 feet in Ospwagan Lake.

The pumphouse floor at Pipe Lake Mine is at elevation 624 feet (Geodetic Datum). The possibility of an ice jam on the Taylor River flooding this pumphouse should be examined before diversion occurs.

CITY OF THOMPSON

The City of Thompson receives all its water from the treatment plant owned and operated by the International Nickel Company. The volume of treated water pumped to the City is 1,500 gpm.

The quality of water supplied to the city should be of equal or better quality than that presently provided since the turbidity and color can continue to be removed and the basic quality of the Churchill River water is better than that of the Burntwood River. The projected flows indicate a 10 to 1 ratio of Churchill River to Burntwood River water.

EFFECTS OF STORAGE RESERVOIRS

The effect of storage reservoirs at the potential power sites of Notigi, Wuskwatim and Manasan will be to provide settling ponds for suspended matter in the water which will result in improved water quality at Thompson. As the initial years of operation of the diversion will carry the greatest quantities of debris and scoured clay it is unlikely that these reservoirs will be constructed in time to prevent the worst conditions from occurring at Thompson.

The effect of a dam at the First Rapids will be to raise the maximum water level at Thompson by approximately 0.5 feet. This potential rise can be taken into account in any reconstruction work undertaken on water and sewage facilities.

WASTE DISPOSAL

Main Plant

The sanitary wastes from the main plant are treated in a septic tank and leaching pit. The effluent from this treatment facility after chlorination is discharged to the Burntwood River via the Thompson Lake diversion. The surface run-off from the plant area also enters the diversion.

Industrial process wastes from the Inco plant complex at the City of Thompson and Birchtree Mine all enter the Burntwood River either via the Thompson Lake diversion or the tailings pond. The volume of these wastes including mine waters is about 20,000 g.p.m. These wastes contain small quantities of dissolved contaminants and the diversion of the Churchill River into the Burntwood River will provide additional dilution for such wastes which reach the river. This effect will be beneficial to the Burntwood River downstream from Thompson.

The various outfalls to the Thompson Lake diversion system and the tailings pond overflow will not be affected by the raised water level in the Burntwood River. The secondary mine shaft associated with the main mine is served by a sewage lagoon which is located adjacent to the tailings area.

BIRCHTREE MINE

The mine waters and treated sanitary wastes from the Birchtree Mine are all pumped into a creek which is tributary to the Thompson Lake diversion. This should not be affected by diversion.

PIPE LAKE MINE

The Pipe Lake Mine sewage is treated and discharged into the Taylor River and should be unaffected by diversion.

CITY OF THOMPSON

The City of Thompson has two sewage treatment facilities. A primary treatment plant serves the main portion of the City and an aerated lagoon serves the westerly portion of the city.

The aerated lagoon discharges into a creek which is tributary to the Thompson Lake and should be unaffected by diversion.

The Primary Treatment Plant, located near the Burntwood River downstream from the city, discharges into the river via a 15 inch corrugated metal pipe. The invert of this outfall is elevation 606 feet (Geodetic). This outfall is located on the outside bend of the river just downstream from the rapids at Thompson and may be subjected to erosion damage once diversion occurs. A new structure will be required for this outfall to protect it from bank erosion. The water level projected for this area will be in the 613 to 615 foot range.

The city has an emergency sanitary sewage overflow at the Riverside Pumping Station. The invert of this outfall is elevation 604 feet (Geodetic Datum). This pipe is laid in the bed of a creek discharging to the river.

A simple modification may be necessary to ensure continued trouble free operation. Storm outfalls are above the projected high water stages.

RECOMMENDATIONS

1. The redesign of the Thompson and Birchtree pumphouses should be undertaken so that reconstruction can be completed before diversion occurs.
2. The International Nickel Company should undertake a program of testing to accurately determine the effect of increased suspended matter in the water used in the milling and refining processes.
3. Water level studies should be made to predict the future levels of the Taylor River at the Pipe Lake Mine pumphouse.
4. The City of Thompson should prepare a design for a new outfall structure for the main sewage plant.

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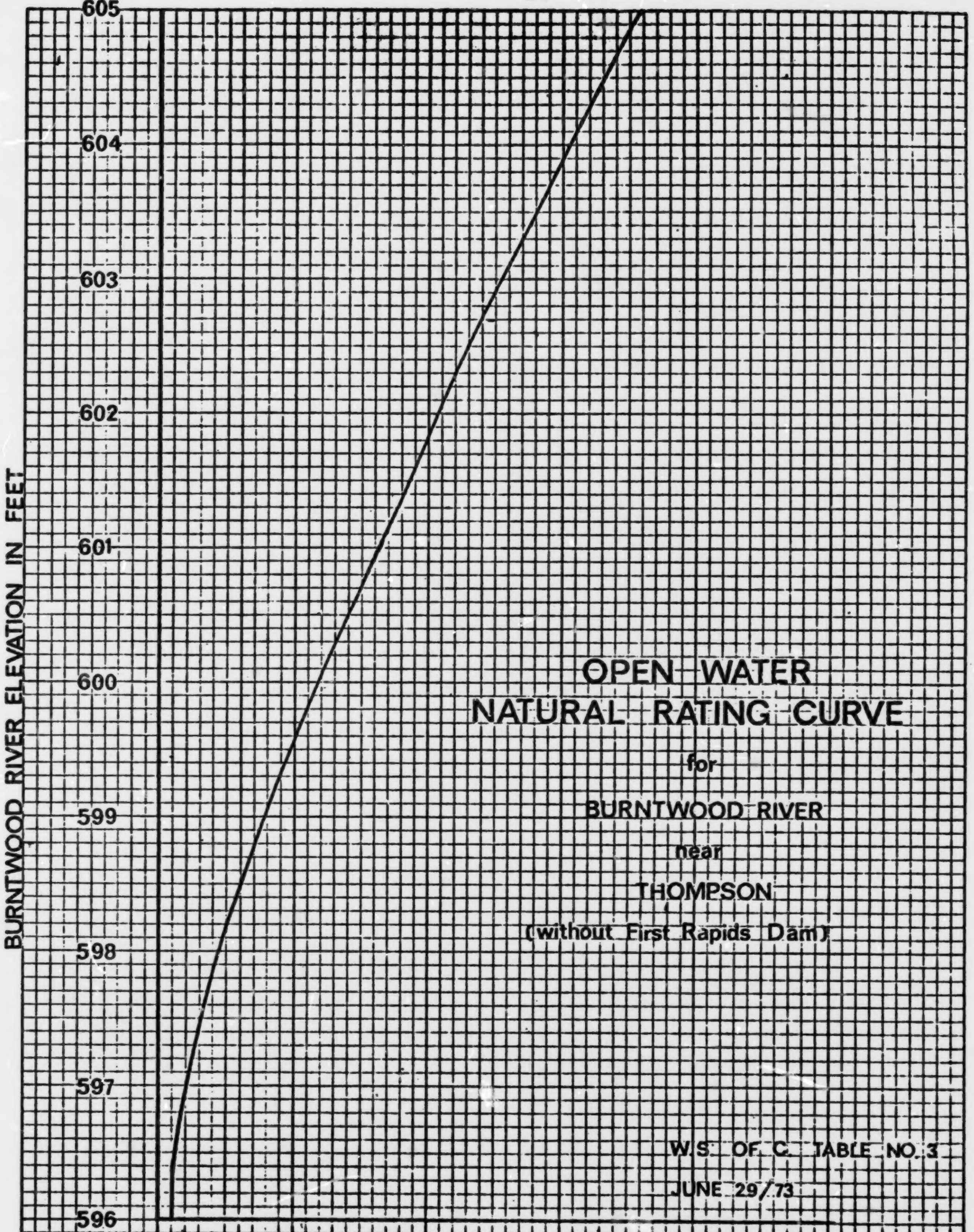
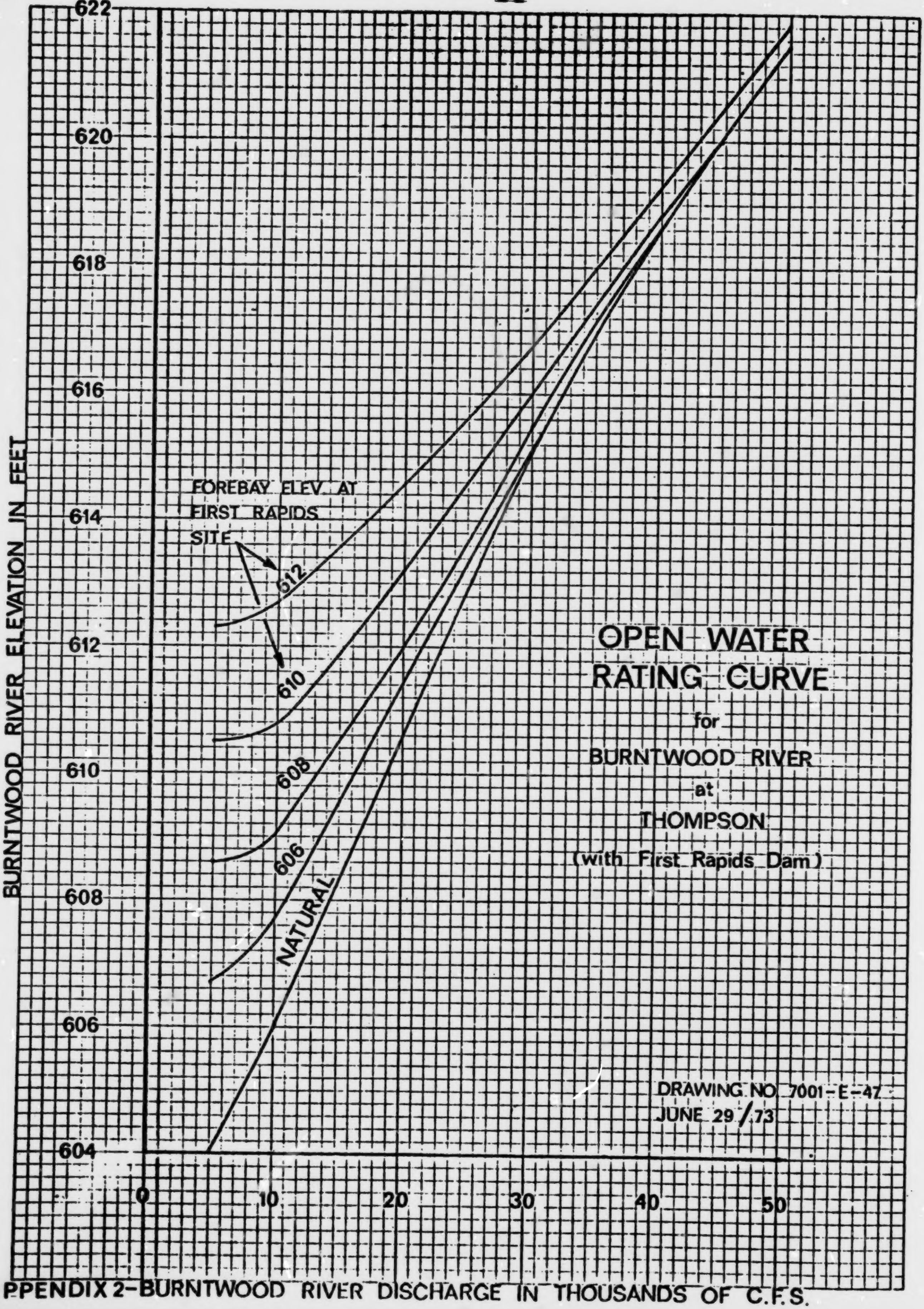
   J. M. Wigharm October 1973



OPEN WATER
NATURAL RATING CURVE
for
BURNTWOOD RIVER
near
THOMPSON
(without First Rapids Dam)

W.S. OF C. TABLE NO. 3
JUNE 29/73

APPENDIX 1-BURNTWOOD RIVER DISCHARGE IN THOUSANDS OF C.F.S.



APPENDIX 2-BURNTWOOD RIVER DISCHARGE IN THOUSANDS OF C.F.S.

APPENDIX 3

COPY

THE INTERNATIONAL NICKEL COMPANY
OF CANADA, LIMITED
MANITOBA DIVISION

A. H. RICHARDSON
Assistant to the General Manager

THOMPSON, Manitoba
R8N 1P3

October 20, 1972

Mr. H. D. Johnston,
Regional Director,
Environment Canada,
5320 - 122nd Street,
EDMONTON, Alberta.
T6H 3S5

Dear Sir,

RE: Water Consumption & Plant Discharge - Volumes

In reply to your recent verbal request to me for current water flows, our estimated average consumptions and discharges are as follows:

(a) Water Consumption

Area	Flow	Source
1. Thompson Mine (T-1 & T-3)	1000 USGPM	Burntwood River
2. Thompson Plant	24000 USGPM	Burntwood River
3. Birchtree Mine	1400 USGPM	Burntwood River
4. Pipe Mine	1000 USGPM	Taylor River
TOTAL	27400 USGPM	

(b) Mine & Plant Discharge

Area	Flow	Receiving Body
1. Thompson Mine Water (T-1 & T-3)	750 USGPM	Thompson Lake
2. T-3 Surface Plant Sewage	55 USGPM	Tailings Basin (Via Lagoon)

..... /2

(b) Mine & Plant Discharge (Cont'd)

	Area	Flow	Receiving Body
3.	Thompson Plant Effluent	14300 USGPM	Thompson Lake
4.	Thompson Plant Sewage	200 USGPM	Thompson Lake (via septic tanks, leaching pits and chlorination)
5.	Thompson Mill Tailings	7000 USGPM	Tailings Basin
6.	Birchtree Mine Water	1200 USGPM	Thompson Lake
7.	Birchtree Mine Sewage	43 USGPM	Thompson Lake (via Lagoon)
8.	Pipe Mine Water (Open Pit)	900 USGPM	U. Ospwagen Lake
9.	Pipe Mine Sewage	12 USGPM	U. Ospwagen Lake (treated and chlorinated)
	TOTAL	25460 USGPM	

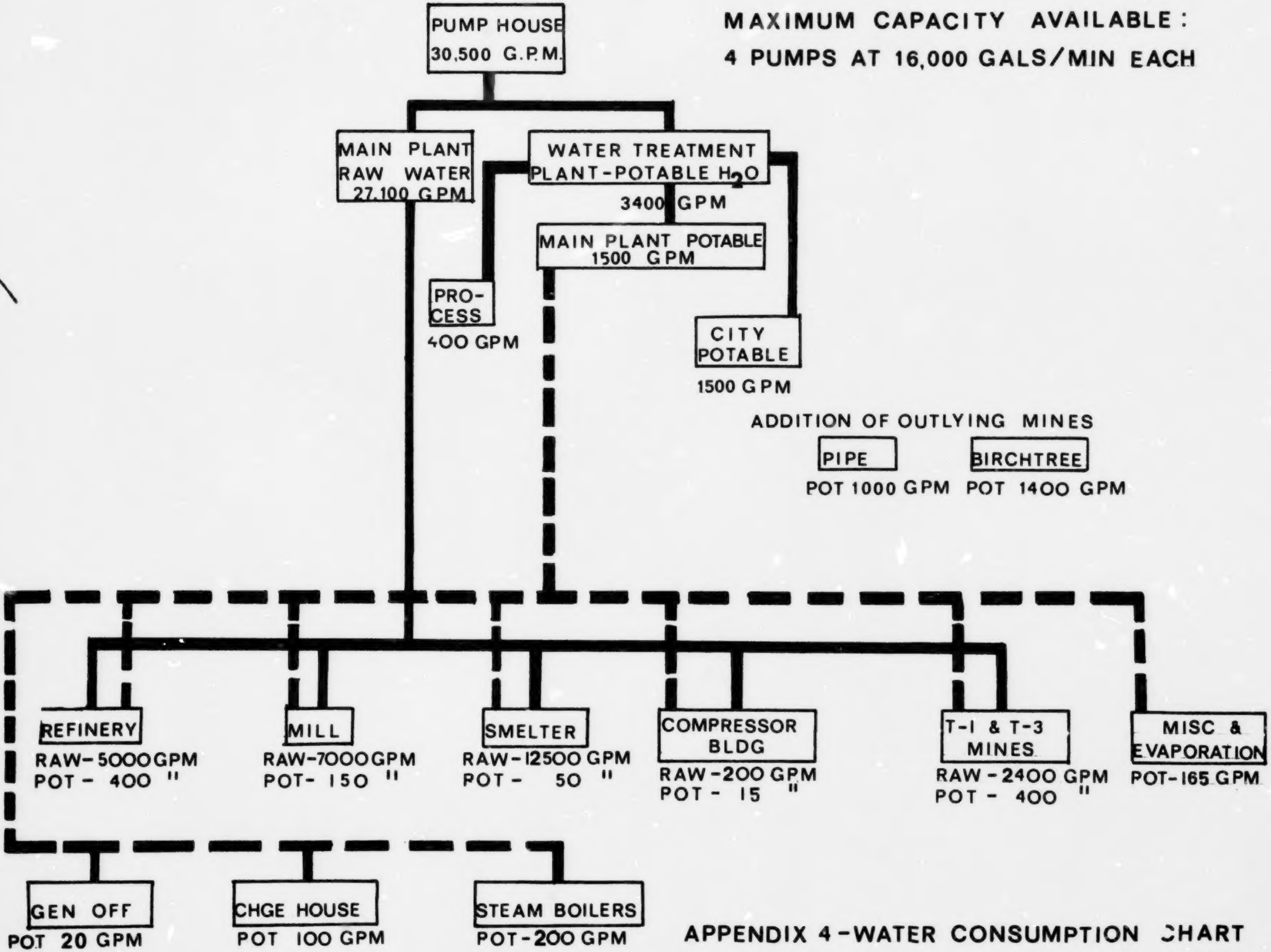
Evaporation, (cooling towers, plating tanks, etc.) stack losses, mine ventilation losses, mine cemented sandfill entrainment, condensate losses, potable water losses and natural seepage to the mines have not been included in the above accounting.

Note that both Thompson Lake and the Tailings Basin discharge to the Burntwood River.

Yours very truly,

Signed

A. H. Richardson,
Assistant to the General Manager


PUMP HOUSE
30,500 G.P.M.
MAIN PLANT
RAW WATER
27,100 GPM
WATER TREATMENT
PLANT-POTABLE H_2O
3400 GPM
MAIN PLANT POTABLE
1500 GPM
PRO-
CESS
400 GPM
CITY
POTABLE
1500 GPM
ADDITION OF OUTLYING MINES
PIPE
POT 1000 GPM
BIRCHTREE
POT 1400 GPM
REFINERY
RAW-5000GPM
POT - 400 "
MILL
RAW-7000GPM
POT- 150 "
SMELTER
RAW-12500 GPM
POT - 50 "
COMPRESSOR
BLDG
RAW-200 GPM
POT - 15 "
T-1 & T-3
MINES
RAW-2400 GPM
POT - 400 "
MISC &
EVAPORATION
POT-165 GPM
GEN OFF
POT 20 GPM
CHGE HOUSE
POT 100 GPM
STEAM BOILERS
POT-200 GPM

MAXIMUM CAPACITY AVAILABLE:
4 PUMPS AT 16,000 GALS/MIN EACH

APPENDIX 4 - WATER CONSUMPTION CHART

INCO AT THOMPSON - 1972

APPENDIX 5

COPY

Province of Manitoba
Department of Mines, Resources and Environmental Management
Water Resources Branch

693 Taylor Avenue
Winnipeg, Manitoba
R3M 2K2

July 30, 1973
File: 8.6

Dr. I. W. Dickson
Study Director
Lake Winnipeg, Churchill and
Nelson Rivers Study Board
693 Taylor Avenue
Winnipeg, Manitoba
R3M 2K2

Dear Dr. Dickson:

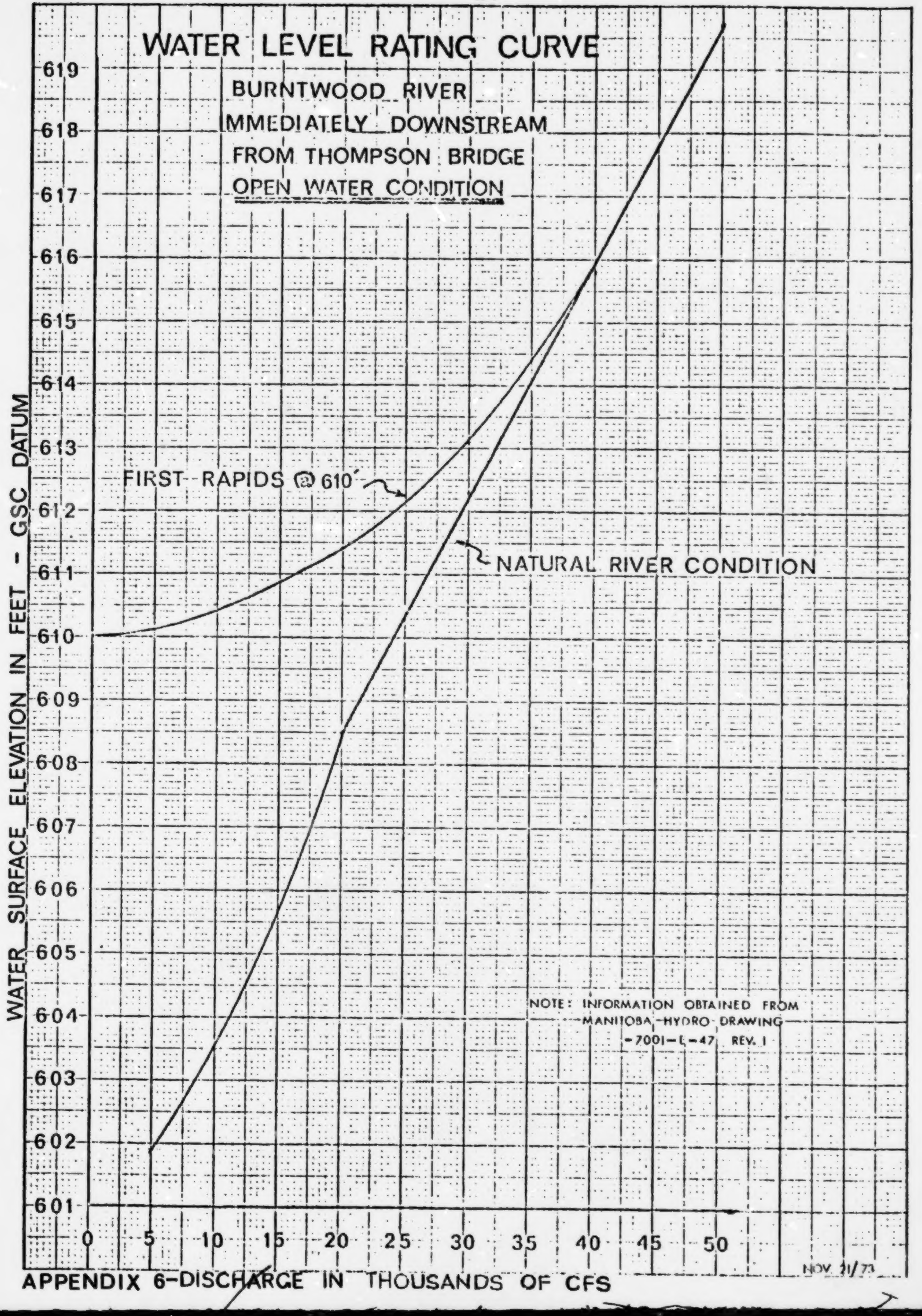
In response to a request by Mr. R. Lyon for a verification of the elevation of Ospwagan Lake, we arranged to carry out a spirt level survey from a geodetic bench mark in Thompson to the site of the recently removed dam at the outlet of Upper Ospwagan Lake. The survey showed that on July 25, 1973, the level of Lower Ospwagan Lake at Boy Scout Camp Dock was 616.45. This elevation is based on a geodetic survey Bench Mark in Thompson.

Yours truly,

Signed

G. H. MacKay, P. Eng.
Head, Water Resources Section

GHM/lz


WATER LEVEL RATING CURVE
BURNTWOOD RIVER
IMMEDIATELY DOWNSTREAM
FROM THOMPSON BRIDGE
OPEN WATER CONDITION
FIRST RAPIDS @ 610'
NATURAL RIVER CONDITION
NOTE: INFORMATION OBTAINED FROM
MANITOBA HYDRO DRAWING
-7001-E-47 REV. 1
WATER SURFACE ELEVATION IN FEET - GSC DATUM
619
618
617
616
615
614
613
612
611
610
609
608
607
606
605
604
603
602
601
0
5
10
15
20
25
30
35
40
45
50
DISCHARGE IN THOUSANDS OF CFS
NOV. 21/73

APPENDIX 6

APPENDIX 4 - L

LAKE WINNIPEG REGULATION - CHURCHILL RIVER DIVERSION - TRANSPORTATION AND NAVIGATION STUDY

LAKE WINIPEG REGULATION-CHURCHILL RIVER DIVERSION
TRANSPORTATION AND NAVIGATION STUDY

by

K. A. ROSIN, F. F. SACCOMANNO and S. TRACHTENBERG
Faculty of Administrative Studies
University of Manitoba
Winnipeg, Manitoba
April, 1973

for

THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SPECIAL NOTE

THE CONCLUSIONS AND RECOMMENDATIONS CONTAINED IN THIS APPENDIX ARE THOSE OF THE AUTHOR(S) AND ARE NOT NECESSARILY THE SAME AS THE CONCLUSIONS AND RECOMMENDATIONS OF THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD AS EXPRESSED IN THE SUMMARY REPORT AND THE TECHNICAL REPORT.

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ACKNOWLEDGEMENTS

The authors wish to acknowledge the assistance of the individuals, agents of government and companies listed below.

1. Groups and Individuals Contracted to the Study Board

Forestry Branch, Manitoba Department of Mines, Resources and Environmental Management.

Parks Branch, Manitoba Department of Tourism, Recreation and Cultural Affairs.

Water Resource Branch, Manitoba Department of Mines, Resources and Environmental Management.

Mr. K. Weagle, Resource Management Branch, Environment Canada.

Dr. V. J. Galay, Department of Civil Engineering, University of Manitoba.

2. Provincial Government Agencies

Northern Transportation Group, Economic Planning Branch, Department of Mines, Resources and Environmental Management.

Manitoba Department of Highways.

Co-operative Branch, Department of Co-operative Development.

ABSTRACT

Due to priorities established by the Study Board, this report concentrates on the general implications to transportation and navigation of Hydro development in the Lake Winnipeg, Southern Indian Lake--Rat-Burntwood Diversion and Lower Churchill River areas.

Each of the above areas is considered separately with the method of analysis used for each being basically the same. The first phase of each study area analysis consists of an inventory of the existing transportation infrastructure as well as a discussion of the physical effects of Hydro development on this infrastructure.

Subsequently the resource base (including recreation) in each study area is outlined as well as the existing methods of removing particular resource products. A general discussion of the Hydro development implications is also included.

The existing transportation services to the communities in each study area are examined and the possible modifications to these services resulting from Hydro development are briefly discussed.

Subject to this analysis, the general impact of Hydro development on transportation and navigation in each study area is assessed and (where appropriate) conclusions are drawn.

PART ONE:
SUMMARY

I Recommendations

As a result of this general study a number of recommendations are presented concerning the effects of Hydro development on transportation and navigation in the study areas examined (Lake Winnipeg, Southern Indian Lake--Rat-Burntwood Diversion route and the Lower Churchill River):

(a) The section of Provincial Road 391 north of Thompson which will be flooded as a result of the Manasan forebay should be upgraded and/or rerouted prior to the construction of the Manasan control structure-generating station.

(b) The design of the Hydro all-weather access road which will connect Ruttan Lake with South Bay should allow for its use post regulation as an initial link in a possible all-weather road connection with South Indian Lake community.

(c) Partial or total inundation of islands on Southern Indian Lake as a result of regulation, may necessitate a program of identification and marking of these islands as an aid to navigation.

(d) Sites which will provide shore-line accessibility post regulation should be included in any clearing program for Southern Indian Lake.

(e) A more detailed examination of the flow conditions post regulation which may affect the operation of the seaplane bases at Nelson House, South Indian Lake and Thompson should be undertaken.

(f) A more detailed analysis of present and potential resource product traffic in the Southern Indian Lake--Rat-Burntwood study area would be necessary before any conclusions can be drawn with respect to the effect of Hydro development on this traffic.

(g) The formation of slush ice in Churchill Harbour, as possibly modified by the Churchill River diversion, can only be fully understood after a detailed ice-formation study has been undertaken.

(h) The effect of the Churchill River diversion on sedimentation and subsequent dredging costs in Churchill Harbour can only be fully understood after a detailed examination of this factor has been undertaken.

(i) The findings which would result from any studies associated with slush ice formation and sedimentation and dredging costs could form the basis for an overall evaluation of the impact of Hydro development on the Port of Churchill.

II Objective

The objective of this general study is to investigate the implications of Hydro development for existing and proposed transportation and navigation facilities and services in the designated study areas.

III Terms of Reference

(a) An examination of the probable effects on transportation and navigation of the planned Hydro development program.

(b) As a result of priorities established by the Study Board, this report is submitted subsequent to the Outlet Lakes Transportation and Navigation Study.

(c) This report includes an overview of each study area (Lake Winnipeg, South Indian Lake--Rat-Burntwood Diversion and Lower Churchill River) which may form the basis for a more detailed investigation.

IV Study Areas

The three study areas considered in this report include:

(a) Lake Winnipeg--from the Red River Delta to the northern extremity of the Lake including all communities and transportation infrastructure adjacent to the Lake (Map I).

(b) Southern Indian Lake--Rat-Burntwood Diversion--Southern Indian Lake, the Rat River, and the Burntwood River as far as First Rapids, including all communities and transportation infrastructure in the area (Map IV).

(c) Lower Churchill River--the Churchill River from Missi Falls to Hudson Bay, including all related communities and transportation infrastructure (Map VII).

V Method of Approach

This report contains a general overview of the above mentioned study areas. The approach taken is that of descriptive analysis and evaluation as opposed to quantitative analysis. No attempt is made to investigate a particular aspect of the Hydro development implications to transportation and/or navigation in an intensive manner. It was deemed more beneficial, for the purposes of this report, to obtain an overall general consensus of these Hydro development implications.

For each study area, the initial phase of the approach examines the major features of Hydro development and the immediate physical implications of these features to their surroundings. This is undertaken in order to provide the basis for a subsequent assessment of the impact of this development to transportation and navigation in each study area.

In each study area, the transportation infrastructure is inventoried; subsequently an examination of the physical effects of Hydro development on this infrastructure is undertaken.

A general analysis is then made of the existing and potential resource base in the three study areas both in terms of area delineation and significance of resource. These resources include: fish, forestry, furs and minerals. Where information was available, the existing methods of removing the resource products from the study areas were examined and a general identification made of the possible implications of Hydro development to these removal methods.

A brief examination is then made of the potential and existing recreation sites in each study area. The accessibility which could be provided to these areas as well as any detrimental effects to existing methods of access, resulting from Hydro development are also considered in general terms.

As a result of the possible complexity of the implications of Hydro development to the Port of Churchill, an analysis of this facility was undertaken as a sub-section of the Lower Churchill Study Area.

PART TWO:
REPORT

I Objectives and Terms of Reference

As a component of the overall study undertaken by the Lake Winnipeg, Churchill and Nelson Rivers Study Board, this report contains the results of an investigation into the implications of the hydro-electric power development program proposed by Manitoba Hydro for existing and proposed transportation and navigation facilities and services in the study areas--Lake Winnipeg, Southern Indian Lake--Rat-Burntwood Diversion and the Lower Churchill River. These areas were not examined in the Outlet Lakes Transportation and Navigation Study, previously submitted.

The initial phase of the present study will attempt to determine the physical impact of the Hydro development on the transportation infrastructure now in existence. Subsequently, the effects of this development on the service aspect of transportation will be outlined.

Envisaged in the terms of reference is an examination and analysis of the probable effects on transportation and navigation which may result from the planned Manitoba Hydro power development including the diversion of the Churchill River and the regulation of Lake Winnipeg.

As a result of the priorities established by the Study Board, this report is submitted subsequent to the aforementioned Outlet Lakes Transportation and Navigation Study, and includes an investigation of the implications to transportation and navigation, resulting from Hydro development, for the three previously mentioned areas (Lake Winnipeg, Southern Indian Lake--Rat-Burntwood Diversion and the Lower Churchill River). Because of the nature of the investigation envisaged in the terms of reference a detailed analysis of each of the above areas has not been undertaken. This report includes an overview of each area which may be used as a basis for more intensive investigation.

II STUDY AREAS

In order to facilitate analysis, this report concentrates on three separate study areas.

A. The Lake Winnipeg Study Area

This area includes the Lake and its immediate surroundings as illustrated on Map I.

A list of the communities bordering the Lake may be found in Table I along with the corresponding population of each.

This area is well served by the provincial highway network; the southern section of this area contains branches of both the Canadian National and Canadian Pacific Railways (Map II). The major marine freight receiving centers on Lake Winnipeg include Matheson Island, Berens River, Bloodvein and Poplar River (Map II). All main air strips and sea plane bases as well as the major scheduled air route in the area are shown on Map III.

B. The Southern Indian Lake--Rat-Burntwood Diversion Study Area

This study area includes Southern Indian Lake from Missi Falls to Leaf Rapids as well as the Rat-Burntwood Diversion route from South Bay (Southern Indian Lake) to First Rapids (Map IV).

The communities of interest in this area include: Leaf Rapids (population 600), South Indian Lake (population 590), Nelson House (population 1300), and Thompson (population 20,000). The figure for Nelson House includes the Indian Reservation population (I.R. 170).[1]

---

[1] Lake Winnipeg, Churchill and Nelson Rivers Study, Study Area Facts 1972.

TABLE I

COMMUNITIES IN THE LAKE WINNIPEG STUDY AREA

COMMUNITY	POPULATION
Arnes	
Camp Morton	
Gimli	1986*
Hnausa	71**
Matlock+	202*
Ponemah+	
Riverton	795*
Sandy Hook	136**
Sans Souci	
Whytewold+	
Winnipeg Beach	661*
Beaconia	62**
Belair	
Ft. Alexander++	1520**
Grand Beach	
Grand Marais	334**
Hillside Beach	
Patricia Beach	
Scanterbury++	347**
Victoria Beach	70**
Anama Bay	
Calders Dock	
Gull Harbour	
Hecla	
Jackhead++	187**
Koostatak	
Matheson Island	122**
Pine Dock	112**
Berens River	942**
Bloodvein++	373**
Hole River++	302**
Manigotagan	186**
Poplar River++	337**
Grand Rapids	500**

[+] Matlock, Ponemah and Whytewold are collectively known as Dunottar and the population as given under Matlock is for Dunottar.

[++] Indian Reserves

[*] 1971 Census Figures

[**] 1966 Census Figures

Note: All unlisted populations are less than 50.

Land access to a portion of this area will be provided by the Thompson to Lynn Lake extension of Provincial Road 391, presently under construction (Map V). Map V also illustrates the major marine freight facilities in the study area. Several commercial air routes serve the study area (Map VI) and charter service to the area is available from virtually any major airstrip or seaplane base in the North. The major landing facilities in the area for both wheeled and float equipped aircraft are also illustrated on Map VI.

C. The Lower Churchill River Study Area

Included in this study area is the Churchill River from Missi Falls to Hudson Bay (Map VII). The only community in this area is Churchill with a population of approximately 3500.[1]

The sole means of land access to this area is by the Hudson Bay Branch of the Canadian National Railway which connects Churchill with points south (Map VIII). There is regularly scheduled air service to Churchill from Winnipeg (Map VIII). The facilities for seaplanes and wheeled aircraft in this area are illustrated on Map VIII.

---

[1] Lake Winnipeg, Churchill and Nelson Rivers Study Board, "Study Area Facts," 1972.

III LAKE WINNIPEG STUDY AREA

A. Major Features of Hydro Development and Immediate Physical Implications

The regulation of Lake Winnipeg is desirable, according to Manitoba Hydro, for two basic reasons:

> "(a) to prevent the lowest levels and to reduce the highest levels to optimize use of the Lake and its associated resources.
>
> (b) to be able to deal with emergency situations respecting water levels as and when required rather than leaving at the mercy of the unpredictability of natural conditions."[1]

The regulation involves the construction of a control structure and generating station at Jenpeg as well as a possible control structure on the East Channel of the Nelson River. Coupled with these structures are three man made diversion channels: the 2-Mile Channel, the 8-Mile Channel and the Ominawin By-Pass, as well as improvements to the West Channel of the Nelson River.

The construction of the aforementioned control structures will allow Manitoba Hydro to use the Lake as a reservoir to store water in the summer for release (to produce Hydro electricity) during the high demand winter months when normal flow on the Nelson River is low. In so doing all water bodies upstream of Jenpeg and the possible East Channel site (with the exception of Kiskitto Lake), including Lake Winnipeg, will be regulated within the range of elevations 711 to 715 feet.[2]

---

[1] Province of Manitoba: "Program for Regulation of Lake Winnipeg," January, 1972.

[2] Discussed in greater detail in the Outlet Lakes Transportation and Navigation Study submitted earlier.

The range of Lake Winnipeg water level elevations which will be experienced after regulation is much less than the historical maximum and minimum values of 717.6 feet and 709.2 feet respectively. More significantly the percentage of time during which the 711 to 715 feet range will exist after regulation is 90 per cent as compared to 76 per cent for historical natural conditions. Also at no time will the level drop below 711 feet after regulation as compared to 12 per cent for recorded conditions.[1]

With regard to the possible flooding caused by regulation, according to a report by the Manitoba Department of Mines, Resources and Environmental Management,

> "The indicated effect of the licensed regulation of levels of the lake within the 711 - 715 elevation range on reducing average annual flood damages to properties along the Lake is $9000 for the long term period considered (1928-1966) but results in an average annual benefit of $22,000 for the period 1942-1966. The risk of failure of the existing temporary dyking system is reduced."[2]

B. Effects of Hydro Development on the Transportation Infrastructure

This section of the report examines the effects of Hydro development on the transportation infrastructure in the Lake Winnipeg study area. For the purposes of this examination, the infrastructure is divided into six categories: all-weather roads, winter roads, railways, navigation, seaplane landing bases and airstrips. For each category of the infrastructure, the physical effects on the existing system are considered as well as possible modifications to this system as a result of Hydro development.

---

[1] Province of Manitoba: "Program for Regulation of Lake Winnipeg," January, 1972.

[2] Water Resources Branch, Manitoba Department of Mines, Resources and Environmental Management: "Effect of Lake Winnipeg Regulation on Flood Damages," 1968.

(1) All-Weather Roads: The all-weather roads in this study area fall into three general classifications (Map II):

(a) Provincial Trunk Highways: Roads in this category meet several standards, such as vertical and horizontal alignment sufficient to provide safety at speeds of sixty to seventy miles per hour. The roadway may be two or four lanes and the surface is paved with asphalt or concrete.

In the Lake Winnipeg study area Provincial Trunk Highways 8, 9, 12, 59, 11 and 6 fall within this classification.

(b) Provincial Roads: Roads in this category meet minimum vertical and horizontal alignment specifications to provide safety at speeds of sixty miles per hour. The roadway consists of two lanes and the surface is either paved asphalt or gravel.

The roads or sections of roads which fall into this classification in the Lake Winnipeg study area include: Provincial Roads 232, 320, 225, 591, 222, 233, 234, 319, 504, 304, 224, 513, 329.

(c) Local (connecting) Roads: This road classification has the lowest standards of the three road types with vertical and horizontal alignment specifications to provide for travel at fifty to sixty miles per hour. The roadway is two lanes and either of gravel or compacted earth.

Many small sections of road in the Lake Winnipeg study area, too numerous to mention, fall within this classification. Two longer sections of this road type run from PR224 to the Jackhead area and from PTH 6 to Long Point.

(d) Effects of Hydro Development on all-weather roads: In terms of detrimental effects to the above roads, caused by flooding, as a result of Hydro development, it may be stated with a reasonable degree of certainty that since the maximum high water level under regulated conditions is about two feet below the recorded natural maximum conditions, no increased damage should result.

Some isolated local roads (category (c)) in the south basin which are close to the water's edge could experience flooding, resulting from a combination of high water levels and wind set up, after regulation. However, these roads usually experienced such flooding during unregulated conditions as well. This type of flooding may even be diminished after regulation due to the lowering of the maximum possible water level.[1]

(2) Winter Roads: In the winter of 1972-73 only one winter road served the Lake Winnipeg study area. The main route of this road is shown on Map II. Branches of this main winter road serve the communities of Berens River and Bloodvein on Lake Winnipeg.

Since the routes of the branch winter roads serving Berens River and Bloodvein do not lie to any extent on the ice of Lake Winnipeg, it may be safe to assume that these roads will be unaffected by possible alterations in ice formation as a result of Hydro development. It may therefore be concluded that the winter road branches serving the aforementioned Lake Winnipeg communities will not be adversely affected by regulation of the Lake.

(3) Railways: Both the Canadian National and Canadian Pacific Railways have branch lines in the study area (Map II). The Canadian Pacific Railway branch line runs north on the west shore of Lake Winnipeg from Winnipeg to Riverton. The Canadian National line runs north east from Winnipeg to Beaconia and Pine Falls.

The location of both rail lines is such that they are well above the maximum elevation of the Lake under regulated conditions (715 feet) and thus will remain unaffected by regulation.

---

[1] Based on information obtained from Water Resources Branch, Department of Mines, Resources and Environmental Management.

(4) Navigation:

(a) Navigation Routes: At present, navigation is possible from St. Norbert, via the St. Andrews Lock, along the Red River to Lake Winnipeg and as far north as Whiskey Jack Portage on the north end of Playgreen Lake.

Most marine freight destined for communities on Lake Winnipeg and the Outlet Lakes is shipped from Selkirk (downstream of the St. Andrews Lock) or Winnipeg.

The average Lake depth varies from fifteen feet at the extreme southern end to eighty feet in the northern basin. The minimum navigable depth of Lake Winnipeg (with the exception of the Red River Delta) is twenty feet. This minimum depth occurs for a length of two miles in the Narrows area.[1]

The normal length of navigation season on the Lake is approximately five months, from June to October, with such conditions as current flow and inflows of warm water having a great bearing on the exact opening and closing dates. Further to this, as noted by "Royal Commission Inquiry into Northern Transportation," the availability of navigational aids together with the desirability of marine carriers to operate earlier or later than the average beginning or end of season, govern the length of the navigation season.

The navigation route on Lake Winnipeg used by the principle marine freighters extends from Winnipeg or Selkirk via the Red River to Matheson Island, Bloodvein, Berens River, Poplar River and points north (in the Outlet Lakes). Map II illustrates this route.

The regulation of Lake Winnipeg to the range of elevation 711 to 715 feet will not alter the route taken by the principal marine freight carriers since the regulated levels are well within the recorded elevations (709.5--717.6 feet) and as such will not affect [illegible] navigable depths of the Lake.

---

[1] R. W. Newbury, et al., "Navigable Waterways of Manitoba," 1969.

(b) Navigation aids: Aids to navigation on inland waterways are constructed, maintained and repaired by the Federal Department of Public Works, Marine Branch. These aids are operated by the Ministry of Transport. Approximately seventy-eight aids to navigation are in operation during the ice free season on Lake Winnipeg. A listing and description of these installations may be found in the publication "List of Lights, Buoys and Fog Signals Inland Waters West of Montreal and East of British Columbia" prepared by the Federal Ministry of Transport. In addition to the above navigational aids, several breakwaters have also been constructed to protect various wharf facilities. Table II contains a listing of these structures and their location.

(c) Marine Freight Facilities: Facilities for the handling of freight exist at each location served by the major marine freight carriers (Matheson Island, Bloodvein, Berens River and Poplar River, Map II). Other wharves have been constructed at various locations along the Lake to serve both recreational boating and unscheduled freight handling. A list of the wharf facilities constructed by the Federal Department of Public Works is found in Table II.

(i) Matheson Island: This community contains two wharves, both built by the Federal Department of Public Works: at the community of Matheson Island and at Matheson Island Landing. The former facility has been constructed on two levels, the upper deck level is at elevation 719.0 feet while the lower deck level is at 716.6 feet. The wharf at Matheson

TABLE II

DEPARTMENT OF PUBLIC WORKS[1]
MARINE STRUCTURES ON
LAKE WINNIPEG

LOCATION	STRUCTURE	DECK ELEVATION
Arnes	Wharf	718.5
Berens River	Wharf	718.0
Calder's Dock	Wharf	719.0 upper 717.0 lower
Gimli	Wharf	719.2
	Timber Breakwater	717.0
	Steel Breakwater	718.0
Grand Rapids	Wharf	718.9
Gull Harbour	Wharf	718.0
Hecla	Wharf	718.5
Hnausa	Wharf	718.0
	Breakwater	720.0
Matheson Island	Wharf	719.0 upper 716.6 lower
Matheson Island Landing	Wharf	717.5
Matlock	Breakwater	719.0
McBeth Point	Wharf	717.1
Pine Dock	Wharf	718.8
Rabbit Point	Wharf	718.0
Riverton	Wharf	717.0
Red River Mouth	Wharf	719.2
	Training Walls	716.0
Selkirk (Red River)	Wharf	720.0
Selkirk Slough	D.P.W. Shipyard Wharf	721.0 upper 719.0 lower
Victoria Beach	Wharf	720.0
Winnipeg Beach	Breakwater	723.0

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[1] Canada Department of Public Works, Marine Division, 1972.

Island Landing has a deck elevation of 717.5 feet.

Since the elevations of both facilities on Matheson Island are above the maximum regulated level of 715 feet, these structures will not undergo any flooding as a result of Hydro development.

(ii) Bloodvein: The facilities for handling marine freight at this community are very poor, according to a major marine freight carrier. All heavy cargo must be unloaded off barges directly to the shore. Information as to the deck elevation of the wharf which does exist at this community is unavailable. However, the same major marine freight carrier indicated that the structure was well above present water levels and hence should be unaffected by Lake regulation.

(iii) Berens River: The wharf at Berens River was constructed by the Federal Department of Public Works. The deck elevation of this structure is 718.0 feet. The structure itself, according to the marine carrier cited earlier, is in fair condition. Therefore since the facilities at Berens River are relatively sound structurally and since its deck elevation is three feet above the maximum regulated level, it is safe to conclude that it will suffer no adverse effects as a result of Hydro development.

(iv) Poplar River: The condition of the marine freight facility at this community is similar to that of Bloodvein River: poor, according to the aforementioned source. Any heavy cargo must be unloaded off the vessels directly to the shore. Again information regarding the deck elevation of the existing facility is unavailable. As with the case of the Bloodvein wharf, however, the previously cited source indicates that the elevation of the deck is such that it will be unaffected by regulation.

(v) Other Wharves: The Lake Winnipeg shore line, especially the southern basin, contains many public and private dock and wharf facilities, too numerous to mention in this report. Table II indicates those wharves built by the Federal Department of Public Works for public use as well as the deck elevation of each. An examination of these deck elevations will illustrate that all are well above the maximum regulated level of 715 feet and thus should not be affected by the Hydro development. The numerous private and public wharves not listed in this Table should not be affected by Lake regulation any more adversely than under natural conditions due to the fact that recorded levels have been as much as 2.5 feet higher and 1.5 feet lower than the regulated maximum and minimum levels respectively.

(5) Seaplane Landing Bases: There are approximately fifteen seaplane bases on or near Lake Winnipeg (Map III). These bases are used primarily by private individuals and charter services. Table III provides a list of the bases as well as latitude, longitude, elevation, orientation, length and general comments on each location.

It will be noted from the Table that, since the seaplane bases are presently at Lake level, being on the Lake itself, fluctuations in levels on the Lake will cause the seaplane base levels to fluctuate correspondingly. It may also be noted from the "General Comments" section of Table III that several of the bases presently have areas of unmarked reefs. It is possible that in times of lower water under regulated conditions (less than 713 feet which is the present Lake level) these reefs may become dangerous since they will be closer to the surface of the Lake. However, since historical recorded levels have been as low as 709.6 feet, under regulated conditions the amount of exposure of the reefs could be less severe.

(6) Airstrips: The airstrips in the Lake Winnipeg study area number approximately eleven (Map III). Of this number, seven are Manitoba Government Land Aerodromes and the remainder are privately owned facilities. Table IV shows the location of each airstrip, its latitude and longitude,

TABLE III

SEAPLANE LANDING BASES ON LAKE WINNIPEG[1]

LOCATION	LAT (N)	LONG (E)	ELEVATION (FEET)	ORIENTATION	LENGTH	GENERAL COMMENTS
Arnes	$50^{\circ}50'$	$96^{\circ}57'$	713	N-S	.75	Ice Aerodrome Only
Berens River	$52^{\circ}22'$	$97^{\circ}02'$	713	N-S	1.5	Many Small Islands
				NNW-SSE	1.2	Break up: May 16
				NNE-SSW	1.0	Freeze up: November 1
				ENE-WSW	1.2	
				WNW-ESE	1.5	
Bloodvein River	$51^{\circ}46'$	$92^{\circ}42'$	713	NW-SE	1.0	Unmarked and Hidden
				E-W	.75	Reefs
				NE-SW	1.0	
Dauphin River	$51^{\circ}58'$	$98^{\circ}04'$	713	E-W	1.5	Unmarked Rocks Near Shore
Gimli	$50^{\circ}36'$	$96^{\circ}58'$	713	-	1.5	Emergency only
Grand Rapids	$53^{\circ}10'$	$99^{\circ}16'$	713	N-S	1.2	Current Fast by Dock
Gull Harbour	$51^{\circ}12'$	$96^{\circ}36'$	713	E-W	1.5	Lake Swell Extreme in Wind
				N-S	2+	
Loon Straits	$51^{\circ}31'$	$96^{\circ}35'$	713	All directions	2	Rough Water and Rock Reefs
Manigotagan	$51^{\circ}07'$	$96^{\circ}19'$	713	WNW-ESE	1.3	Strong Current, Shoal
				N-S	1.7	Rocks, Deadheads
				NW-SE	2.0	
				NE-SW	2.0	
				EW	2.0	
Matheson Island	$51^{\circ}44'$	$96^{\circ}56'$	713	NE-SW	2.0	Break up: May 16
				NW-SE	1.0	Freeze up: November 1

TABLE III cont'd

LOCATION	LAT (N)	LONG (E)	ELEVATION (FEET)	ORIENTATION	LENGTH	GENERAL COMMENTS
Poplar River	$52^{\circ}59'$	$97^{\circ}18'$	713	- -	-	Rocks and Reefs
Princess Harbour	$51^{\circ}52'$	$96^{\circ}52'$	713	NE-SW	-	Unmarked Reefs
Victoria Beach	$50^{\circ}41'$	$96^{\circ}34'$	713	N-S E-W E-W	1.5 2.0 1.0	Break up: May 14 Freeze up: November 5
Wanipigow	$51^{\circ}12'$	$96^{\circ}18'$	713	All directions	2.0+	Unmarked Reefs
Washow Bay	$51^{\circ}24'$	$96^{\circ}53'$	713	N-S E-W	2.0+ 2.0+	Reefs Difficult to See

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[1] Manitoba Flight Information Map

elevation (where available), length (where available), and any general comments about the surface conditions.

Although elevations are given (Table IV) for only the airstrips at Berens River and Poplar River (both are at an elevation of 728 feet), it may be reasonable to assume that none of the facilities in the study area will be adversely affected by the Lake Winnipeg regulation scheme. This assumption is based on the fact that in the absence of evidence to the contrary none of the airstrips have been flooded or otherwise damaged under natural recorded levels which have been as much as 2.5 feet above the maximum regulated level of 715 feet, to be established after implementation of Lake regulation.

C. Effects of Hydro Development on Resource Traffic

The major resources in the Lake Winnipeg study area include: fisheries, forestry and recreation. The following discussion will concentrate on the implications to the transportation requirements of these resources of Lake regulation.

(1) Fisheries: The great portion of the fishing carried out on Lake Winnipeg is of a commercial nature. Prior to the closure of Lake Winnipeg to commercial fishing due to mercury contamination, in the spring of 1970, the average annual amount of fish caught for the years 1965 to 1969 was 7.3 million pounds with an annual value to the fisherman of 1.3 million dollars. The Lake was reopened to fishermen in the spring of 1972. No catch data is available for this season at the present time.

With regard to the impact of Lake Winnipeg regulation on the fishery:

> "It is concluded that any detrimental effects upon the fish stocks attributable to regulation which would reduce the amplitude of the rise of lake level from spring to summer would be counterbalanced by benefits to fish arising from

TABLE IV

LAKE WINNIPEG STUDY AREA AIRSTRIPS[1]

LOCATION	LAT (N)	LONG (E)	ELEVATION (FEET)	LENGTH (FEET)	GENERAL COMMENTS
Anama Bay*	51°58'	98°09'	-	3500	Gravel and clay surface
Berens River*	52°22'	97°01'	728	3500	Gravel on clay surface
Bloodvein River*	51°47'	96°42'	-	4000	Gravel on clay surface, soft when wet
Loon Straits*	51°31'	96°35'			
Matheson Island*					
Poplar River*	52°59'	97°18'	728	2400	Gravel on clay surface, soft when wet
Princess Harbour*					
Arnes**	50°50'	96°57'			
Gimli**	50°38'	97°03'			
Grand Rapids**	53°10'	99°19'			
Riverton**	50°58'	97°01'			

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[1] Manitoba Flight Information Map

* Manitoba Government Land Aerodromes

** Private Land Aerodromes

the generally higher average lake elevation at all seasons."[1]

Therefore it may be assumed that regulation will not alter the Lake Winnipeg commercial fishery with regard to availability of fish stocks in the Lake. The Lake is fished in both the open water season and in winter with the former producing the larger percentage of catch. The fish caught on Lake Winnipeg for commercial purposes in the open water season are taken by boat or barge to Selkirk or Winnipeg and thence by truck to the Freshwater Fish Marketing Corporation plants in Transcona or Selkirk. Since the navigation routes which are presently used will not be affected by the regulation of Lake Winnipeg (section B(4)(a)), the method of collecting and transporting the fish (i.e. barge or boat) should not be altered. The fish caught in the winter months are brought to the major collection points by bombardiers or snowmobiles for furtherance to the above mentioned Freshwater Fish Marketing Corporation plants.

(2) Forestry: The major forest product processor in the Lake Winnipeg study area is Abitibi Manitoba Paper Company Limited of Pine Falls.

In its submission to the Province of Manitoba Inquiry into Northern Transportation in 1967, this company stated that of 176,000 cords of pulpwood involved in its operation, only 7,100 cords were moved by barge. Forest products are removed from the management units in the Lake Winnipeg study area by means of barge to the plant at Pine Falls.

According to the Program for Regulation of Lake Winnipeg:

> "As the new level of Lake Winnipeg will be contained within the limits which existed in the natural condition in the past, no flooding of productive forested land and no adverse effects on forests caused by lake regulation are expected."[2]

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[1] Manitoba Department of Mines, Resources and Environmental Management and Manitoba Hydro: "Program for Regulation of Lake Winnipeg," 1972.

[2] Ibid.

Therefore harvest of pulpwood and other forest products will not be reduced by Lake Winnipeg regulation.

Since the routes used for navigation are unaffected by Lake regulation, it is reasonable to conclude that barge transportation of forest products will be unaltered.

(3) Recreation: By far the most widely used resource in the Lake Winnipeg study area, particularly south of the Narrows, is the recreation afforded by the Lake and its many beaches.

The regulation of Lake Winnipeg within the elevations of 711 to 715 feet will have both advantages and disadvantages in terms of recreation. According to the Program for Regulation of Lake Winnipeg: "...more reliable levels will mean better prediction of the amount of beach that will be available. It also makes more reliable the prediction of flood levels for building locations and other works."[1]

Disadvantages, due to late summer and fall regulated levels which would be generally higher than natural conditions, would be:

"1. A reduced beach capacity
2. An increased probability of high water during the fall storm period."[2]

In terms of the implications to the transportation system which serves the recreation areas on Lake Winnipeg, the regulation of the Lake will not affect the system in a detrimental manner. The local road network will not be affected by regulation to the extent experienced pre-regulated conditions (section B(1)). With regard to recreational navigation:

> "Reduced likelihood of low levels will aid navigation, particularly at some shallow harbours."[3]

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[1] Ibid.

[2] Ibid.

[3] Ibid.

Thus it may be concluded that the navigational aspect of recreation may be improved post regulation and that the local road network which provides access to the recreation sites will not be as seriously affected by high water levels of a post regulation nature.

D. Effects of Hydro Development on Transportation Services to Communities

These "transportation services" include both importation of commodities such as food and fuel and means of access to and from the communities in the Lake Winnipeg study area, (Table I, section IIA)).

Since the transportation infrastructure in the study area (including: all-weather roads, winter roads, navigation routes, airstrips, seaplane bases) is not affected in any adverse manner by the regulation of Lake Winnipeg, it may be reasonably concluded that, in terms of use of this infrastructure for importation of cargo or as a means of inbound or outbound person travel, the effects of Hydro development on transportation services will be minimal.

IV SOUTHERN INDIAN LAKE--RAT-BURNTWOOD DIVERSION STUDY AREA

A. Major Features of Hydro Development and Immediate Physical Implications

The overall Manitoba Hydro development in this area calls for the diversion of the Churchill River via South Bay (on Southern Indian Lake, Map IV) into Issett Lake, the Rat, Burntwood and subsequently the Nelson Rivers in order to, according to Manitoba Hydro, "improve the efficiency of all power stations on the Lower Nelson River by almost 40 percent."[1]

To accomplish this diversion efficiently several control structures and/or generating stations and a diversion channel will be constructed. These facilities and their immediate physical implications to the study area are discussed below.

(1) Missi Falls Control Structure: A control structure will be constructed near the outlet of Southern Indian Lake at a site known as Missi Falls (Map IV). By erecting a control dam at Missi Falls, the main flow of the Churchill River will be diverted through a man made channel (discussed below) into the Rat River and thence via the Burntwood River into the Nelson River. As reported in a Manitoba Hydro News Release, the license received from the Province of Manitoba will permit Hydro "to divert not more than 30,000 cfs of water from the Churchill into the Nelson River. A minimum of 500 cfs must be released from Missi Falls control structure during open water periods and a minimum of 1,500 cfs during the ice covered period."[2]

As a result of the Missi Falls dam, Southern Indian Lake will be raised gradually to an elevation of 847 feet, with a maximum permissable level of 850 feet. During operation as a reservoir, the maximum fluctuation permitted on Southern Indian Lake in any twelve month period will be two feet.[1]

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[1] Manitoba Hydro News Release, January 25, 1973.

[2] Ibid.

(2) South Bay Diversion Channel: This channel will permit the passage of water from the Churchill River at South Bay into the Rat-Burntwood River system (Map IV). The channel will extend for approximately five and half miles in a south westerly direction from South Bay (on Southern Indian Lake) via Grassy Lake, to Isset Lake at the headwaters of the Rat River. The width of the channel for most of its length will be 850 feet. It will begin to diverge approximately one mile from Isset Lake and will attain a width of 2,500 feet at its outflow into Isset Lake.

(3) Notigi Control Structure and Generating Station: The Notigi control structure-generating station will be built at the southern end of Notigi Lake (Map IV). Its purpose will be to regulate all water bodies upstream including Southern Indian Lake to a maximum elevation of 850 feet and to produce a certain amount of hydro-electricity. According to the Manitoba Hydro scheduling plan:

> "At Notigi, it is intended to use the natural inflow into the Rat River basin to raise the elevation from 790 feet to 832 feet by September, 1975. The remaining ponding (to a maximum of 850 feet--authors) would be from the Churchill system via the South Bay Channel, and would be complete by November 1, 1975."[2]

The result of raising the water levels upstream of Notigi control structure will be that from South Bay to Notigi Lake approximately 158.5 square miles of land will be flooded. In the Southern Indian Lake area (including High Rock, Granville and Opachuanau Lakes) approximately 211.7

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[1] Ibid.

[2] Letter from C. J. Goodwin, Director of System Planning Division of Manitoba Hydro to the Study Director, December 14, 1972.

square miles will be flooded.[1]

The main control dam at Notigi will be used as a bridge across the Rat River by the Thompson-Lynn Lake highway (Provincial Road 391).

(4) Wuskwatim, Manasan and First Rapids Control Structures-Generating Stations: These three facilities will be built along the Burntwood River to serve as control structures and hydro electric generating stations.

The Wuskwatim structure will be located at the outflow of Wuskwatim Lake on the Burntwood River (Map IV). The structure at Manasan will be located approximately midway between the Wuskwatim facility and the city of Thompson, on the Burntwood River (Map IV). The First Rapids control structure-generating station will be situated downstream of Thompson (approximately thirty miles) on the Burntwood River (Map IV).

According to sources within the Department of Mines, Resources and Environmental Management, Water Resources Branch, detailed information regarding levels and flows associated with these structures will not be available until April 1, 1973 and as such cannot be included in this report.[2] However, the same source has indicated that "the design of the remaining three dams...is incomplete.... Manitoba Hydro are suggesting the following design forebay levels:

(a) Wuskwatim--800 feet
(b) Manasan--690 feet
(c) First Rapids--610 feet"[3]

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[1] R. H. Lamont, Chief Forestry Inventory, Manitoba Department of Mines, Resources and Environmental Management, December 18, 1972.

[2] Letter to Study Director, December 13, 1972.

[3] Letter to authors from Water Resources Branch, December 5, 1972.

B. Effects of Hydro Development on the Transportation Infrastructure

This section of the report examines the effects of Hydro development on the transportation infrastructure in the Southern Indian Lake--Rat-Burntwood Diversion study area. For the purposes of this examination, the infrastructure is categorized thusly: all-weather roads, winter roads, railways, navigation, seaplane landing bases and airstrips. The physical effects on the existing system as well as possible modifications to the system as a result of Hydro development are considered for each category.

(1) All-Weather Roads: The all-weather roads in this study area fall into three general classifications.

(a) Secondary paved or gravel: roads in this category meet minimum vertical and horizontal alignment specifications to provide speeds up to sixty miles per hour. The roadway consists of two lanes, each lane approximately twelve feet wide with six foot shoulders. The road surface is either paved asphalt or gravel

In the Southern Indian Lake--Rat-Burntwood Diversion area the portion of Provincial Road 391 south of Thompson falls within this classification. The section of Provincial Road 391 from Leaf Rapids to Lynn Lake is currently undergoing upgrading to bring it up to secondary gravel standards (Map V).

(b) Pioneer: the pioneer road forms the initial stage in the construction of a road in the north. Essentially, pioneer status is little more than through-way clearing in wilderness to establish some form of rudimentary connection between points. As a result, the specifications for this category are minimal. The roadway consists of a thirty-four foot wide unmarked strip. The surface material is either gravel or compacted earth. There is no vertical alignment provided on a pioneer road, although horizontal alignment is included in the specifications to facilitate future improvement.

The portions of Provincial Road 391 from Leaf Rapids to Suwannee River and from Thompson to Notigi Lake (with a branch to Nelson House) are presently of pioneer status (Map V). The section of Provincial Road 391 from Suwannee River to Notigi Lake is presently being upgraded to pioneer standards (Map V). The entire Lynn Lake-Thompson road is scheduled to be of secondary status by October, 1973.

(c) Other Roads:[1] these roads are characterized by the fact that they are constructed to provide access to specific areas of activity such as mine sites, hydro sites, etc.

In the Southern Indian Lake--Rat-Burntwood Diversion study area, three sections of road have been identified which may be included in this category (Map V).

A road from Leaf Rapids to Ruttan Lake has been built by the Department of Highways to service the Sherritt-Gordon mine site north of the Lake. This road is currently being extended by the Highways Department to South Bay on Southern Indian Lake (scheduled for completion in October, 1973) to provide access to the Hydro diversion channel construction site and possibly to provide the initial link in a barge operation to the Missi Falls control structure site. A short branch of the Lynn Lake-Thompson road (Provincial Road 391) forty-eight miles east of Lynn Lake to the Barrington River, may be constructed to provide access for a potential barging operation to the Missi Falls control structure site.

It is possible that the Hydro structures at Wuskwatim, Manasan and First Rapids will be serviced using road links with Provinical Road 391. However no definite information regarding these potential roads is avail-

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[1] Information for this section was provided by Manitoba Hydro.

(d) Effects of Hydro Development on All-Weather Roads: The creation of forebays at Notigi, Wuskwatim and Manasan (section IVA(4)) will result in a certain amount of flooding along the Rat-Burntwood Diversion route.

Certain sections of the Thompson to Lynn Lake road (Provincial Road 391) approach the forebays which will be created along the Rat-Burntwood Diversion route. Therefore these sections of road should be examined with regard to possible effects due to flooding (bank instability, erosion and submergence). Possible road sections which may be of concern include the vicinity of: Leaf Rapids, Notigi control structure, Nelson House, and Thompson. Of these, there is only sufficient information on the portion of Provincial Road 391 near the city of Thompson. This section of road is approximately three miles in length and begins a distance of four miles (by road) north of Thompson (see Map V). It is estimated that the reservoir created by the Manasan dam will flood this portion of road, irrespective of any dyking program proposed by the Baracos-Galay report.[1] Therefore some type of rerouting and/or upgrading of the road should take place.

It is assumed that any Hydro roads built to service construction sites are either of sufficient grade to prevent any adverse effects due to high water or are of a temporary nature, for use prior to implementation of regulation and thus will be unusable (due to flooding) post regulation. An example of the latter type of road is the Ruttan Lake-South Bay connection. Portions of this road could be flooded as a result of the Notigi forebay and the diversion of the Churchill River via South Bay. A ramification of this factor is that should this road be built at an elevation above the flood level, it may become the initial link in a future all-weather road to South Indian Lake community, while if it is partially flooded, it will be of little direct use to the people of the community post regulation.

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[1] Based on information received from a discussion with Professor V. J. Galay, Department of Civil Engineering, University of Manitoba.

(2) Winter Roads:[1] in the study area, the Manitoba Department of Highways has constructed a winter road from Notigi to Suwannee River to be open until breakup, 1973 (Map V). This road which connects the completed pioneer status portions of Provincial Road 391 is scheduled for upgrading to secondary status by October, 1973 (section B(1)(b)).

The province has also constructed a winter road from Ruttan Lake road to South Bay with an extension into the community of South Indian Lake, which will be open until breakup, 1973. This road provides access to South Indian Lake community and the Hydro construction site at South Bay during the winter of 1972-73 (Map V). The section of winter road from Ruttan Lake to South Bay will be replaced by an all-weather road by October, 1973 (see section B(1)(c)).

Manitoba Hydro has completed a winter road from South Bay to Missi Falls (Map V). This road will remain open until breakup 1973. In past years access to Missi Falls has been provided from Thompson by winter road. The northern portion of this road forms the largest section of the South Bay-Missi Falls road (Map V). The southern section of the Thompson-Missi Falls winter road (as far as Uhlman Lake) has been abandoned. Until the Missi Falls control structure is completed access overland will be provided to Missi Falls via the South Bay-Missi Falls winter road.

Since the winter roads from Notigi to Suwannee River and Ruttan Lake to South Bay will become all-weather roads by October, 1973 (see above), the only winter roads which may be affected by Hydro development are the South Bay-South Indian Lake and South Bay-Missi Falls connections. The former road is exclusively an overland route (Map V) and as a result should not be affected by altered ice formations on South Bay (Southern Indian Lake). The latter route initially crosses portions of South Bay (Map V) and as such may be affected by changes in the ice regime as a result of regulation. Detailed information on the nature of these changes is unavailable at this time. The greatest percentage of the South Bay-Missi Falls winter road, however, is overland (Map V), and as such should be unaffected by ice conditions on Southern Indian Lake, post regulation.

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[1] Much of the information for this section was provided by Manitoba Hydro.

(3) Railways: In the Southern Indian Lake--Rat-Burntwood Diversion study area the only railway line is the branch of the Hudson Bay Railway which serves the city of Thompson. The portion of this branch which enters the city of Thompson appears to be the only section of rail which could be affected by Hydro development. The Rat-Burntwood Diversion may increase the flow of the Burntwood River at Thompson by 30,000 cfs at times.[1] This could cause alterations to the river banks near the city. However, the alignment of the rail line as it enters Thompson is such that its closest proximity to the Burntwood River is approximately one-half mile. Therefore, it is unlikely that the railway line will incur any adverse affects as a result of Hydro development.

(4) Navigation: Apart from small motor boats and canoes, any navigation in the study area is confined to Southern Indian Lake.

(a) Navigation on Southern Indian Lake: Navigation is possible on the Lake from Leaf Rapids to Missi Falls; the actual navigation routes are as shown on Map V.

The stretch of water from Leaf Rapids to Opachuanau Lake causes certain navigational difficulties at present due to shallow depths. Beyond this area, navigation is possible throughout most of Southern Indian Lake.

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[1] Water Resources Branch, Department of Mines, Resources and Environmental Management.

The extent of the navigation season on the Lake is from approximately the first week in June to the last week in October. Local conditions on the Lake may influence the exact opening and closing dates.

As discussed in Section A, Hydro development will cause the level of Southern Indian Lake to rise to a maximum elevation of 850 feet. Depending on the type of vessel which will be used on the Lake and the present depth of the channels used for navigation, this increase in Lake level could improve the navigability of the above mentioned shallow stretch of water from Opachuanau Lake to Leaf Rapids. There is also the possibility that navigation upstream of Leaf Rapids in the Granville area may be improved by the planned increase in water levels.

Increased water levels on Southern Indian Lake post regulation could result in the total or partial inundation of many islands. This becomes particularly significant in the southern portion of the Lake due to the abundance of small islands in this area. These submerged and/or partially submerged islands could be hazardous to navigation on the Lake. Provisions for marking of these islands as aids to navigation would require their identification and information on the extent to which they may be flooded.

Also of direct concern to navigation is the shore line accessibility which is available after regulation. A specific issue is the flooding of tree stands along the lake shore resulting in the inability of vessels to approach the shore. The clearing specifications applied to Southern Indian Lake make reference to general terms which serve to provide accessibility to shore line at selected points and remove obstructions to navigation.

(b) Marine Facilities--Docks and Wharves: Detailed information concerning the docks and wharves in the study area is unavailable at this time. For the purpose of this report a brief discussion regarding the marine facilities in the study area is included. The docks which are presently in existence in the study area include those at South Indian Lake, Leaf Rapids, Loon Narrows and Missi Falls. To provide access to certain Hydro construction sites two new facilities are proposed for this area (Map V). These include South Bay at the terminus of the Ruttan Lake--South Bay road, and at the terminus of the Barrington River access road. Since Manitoba Hydro plans to transport construction material to Missi Falls by barge in summer the corporation has built a major wharf facility at the latter site. It is expected that the bulk of the water transport associated with Hydro construction will be from South Bay to Missi Falls.

(5) Seaplane Bases and Landing Areas: There are numerous seaplane landing areas in the Southern Indian Lake--Rat-Burntwood study area many of them associated with fishing operations in neighbouring lakes. In this section, however, only those facilities associated with a permanent community or a Hydro construction camp are discussed.

(a) Thompson: The seaplane base at Thompson is situated on the Burntwood River at Lat. 55°46'N, Long. 97°49'W. The base is operated jointly by Ilford-Riverton Airways, Lambair and Manitoba Government Air Services, from approximately the last week in May to the last week in October. Local weather conditions govern the exact dates of freeze up and break up on the Burntwood River at Thompson. Docking facilities, which are available at the site are in good condition.

While landing, caution should be maintained due to fast water on the Burntwood River especially in the vicinity of the bridge crossing of Provincial Road 391.

Since the diversion of the Churchill River into the Rat-Burntwood River system may at times result in an increase of 30,000 cfs above the flow of 4,000 cfs (based on a ten year mean value), as well as an increase in current velocity from 1.0 fps to 2.5 fps (which will increase the fast water problem), this may cause disruption of the seaplane facility at Thompson.[1] Formation of eddies (turbulence) downstream of the bridge (Provincial Road 391) in the vicinity of the seaplane landing area, caused by increased flows post regulation, could contribute to the hazardous conditions by the exertion of lateral forces on the aircraft during landing.[2]

(b) Nelson House: The seaplane base serving Nelson House is situated on Footprint Lake (elevation 780 feet) at Lat. 55°47'N, Long. 98°53'W. The base is operated jointly by Lambair and Illford-Riverton Airway. The usable time span of the facility is similar to that noted for Thompson. The base is served by three docks, two located east of the community and one dock in front of the nursing station, south of the community.

Operating conditions for the Nelson House base are generally good, though caution is required as a result of some reefs in certain areas of Footprint Lake.

As a result of the Churchill River diversion, the water levels on Footprint Lake will be increased to that of the Wuskwatim forebay i.e. approximately 800 feet (section IVA(4)). This factor may remove the hazard to landing caused by reefs presently located near the surface. However rock outcrops and/or low islands which are presently above water may, post regulation, become fully or partially submerged, forming reefs which could present a hazard to landing.

Information regarding increases in current velocity and/or flow characteristics (turbulence) is not available at this time. Therefore no conclusions can be drawn regarding possible effects of these factors on the seaplane base at Nelson House.

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[1] Study Area Facts, Lake Winnipeg, Churchill and Nelson River Study Board, January, 1973.

[2] Information on increased velocities and flows is taken from the Galay-Baracos report on the Burntwood River at Thompson.

(c) Leaf Rapids: The seaplane base serving Leaf Rapids is located at Lat. 56°30'N, Long. 99°58'W, and consists of two landing approaches, N-S 0.5 miles and NE-SW 0.75 miles.

The actual landing site is confined to an area situated between the bridge crossing of the Churchill River (Provincial Road 391) and a stretch of rapids. It is at an approximate elevation of 850 to 855 feet.[1]

As a result of its location and elevation, the seaplane base should encounter no adverse effect either resulting from fluctuations in water level or alterations in current flow, post regulation.

(d) South Indian Lake: The seaplane base serving South Indian Lake is located on Southern Indian Lake at Lat. 56°48'N, Long. 98°57'W. The base is operated jointly by Midwest Airlines, Lambair, and Manitoba Government Air Services. The length of the landing site is approximately two miles and is situated directly south of the community. Docking facilities serving the base are in good condition.

Specific information regarding post regulation current velocities and turbulence in the vicinity of the seaplane base at South Indian Lake is unavailable at this time. However, since the Churchill River will be diverted via South Bay and a diversion channel into the Rat-Burntwood River system, alterations to the existing current flow at the seaplane base (which lies at the northern end of South Bay) may occur with a maximum increase of 30,000 cfs being experienced. The nature of any altered current flow in the vicinity of the seaplane base is unknown and therefore the effects of this factor on the facility cannot be assessed without more detailed information.

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[1] Information received from the Study Board.

(e) Seaplane Landing Areas Associated with Hydro Projects: Detailed information concerning these bases has not been made available at this time. However, since Manitoba Hydro has no immediate plans to construct airstrips at South Bay and Notigi, it is reasonable to assume air service to these sites may be provided by float equipped aircraft.

A major airstrip is planned for completion at Missi Falls by early fall of 1973. Air transport needs until then will be provided by float equipped aircraft. The airstrip at South Indian Lake may serve to provide air transport service to the South Bay project during ice cover periods.

Due to the lack of information regarding the possible use of seaplanes to service Hydro sites (other than Missi Falls) it is not possible to comment further on the implications of Hydro development to any facilities associated with these services.

(6) Airstrips: The Southern Indian Lake--Rat-Burntwood study area has four regular airstrips and one proposed for this year. Construction sites which may be serviced by airstrips (eg. Notigi, Manasan, etc.) are not discussed in this report since Manitoba Hydro has not confirmed any development in this regard.

(a) Thompson: Thompson is the site of one of the major air facilities in northern Manitoba. The airstrip is operated by the Government of Manitoba and is classified under the category IFR (Instrument Flying Rules). This means the facility is operable day and night and under conditions where visibility may be restricted. The strip is located at Lat. 55°48'N, Long. 97°52'W, at an elevation of 704 feet and consists of an asphalt runway 5,400 feet in length. The auxiliary facilities at the airdrome include an airport terminal for passengers and freight as well as radio aids to navigation.

The elevation of the airstrip is approximately fourteen feet, about the suggested Manasan forebay level of 690 feet (section IVA(4)). It has been suggested (in a study conducted by Professors V. J. Galay and A. Baracos of the Department of Civil Engineering, University of Manitoba) that a certain amount of dyking may be required near the south west end of the airstrip to prevent any possibility of flooding of sections of the runway.

(b) Nelson House: The Nelson House airstrip is located on the north shore of Footprint Lake at Lat. 55°45'N, Long. 98°50'W (elevation 830 feet). This facility, owned by the Province of Manitoba has a runway length of 3,000 feet, surfaced with clay and sand which is slippery when wet. The auxiliary facilities include a proposed terminal building and wind direction indicator. There are no runway markers, lighting or navigation indicators.

Since this airstrip is situated approximately thirty feet above the suggested Wuskwatum forebay elevation of 800 feet, no adverse effects should result from Hydro development.

(c) Leaf Rapids: The airstrip at Leaf Rapids is situated at Lat. 56°30'N, Long. 100°00'W and consists of a 4,000 foot runway, with gravel surface. No information is available at present on the elevation of the airstrip. The facility is owned by the Province of Manitoba.

Since the level of the Churchill River at Leaf Rapids is not expected to increase from its present stage (850 feet) it may be assumed that the airstrip will be unaffected by Hydro development.

(d) South Indian Lake: The airstrip at South Indian Lake is owned by the Province of Manitoba and is located at Lat. 56°48'N, Long. 98°55'W. The runway is of clay surface, 2,000 feet in length and there are no auxiliary facilities at the airstrip. No information is available at present on the exact elevation of this airstrip, however its location is 200 yards inland on the east side of the South Bay channel and is above the 850 foot flood contour line.[1] Therefore no effect is anticipated as a result of Hydro development.

(e) Airstrips Associated with Hydro Projects: As mentioned previously, although a major airstrip is planned for completion at Missi Falls by early fall of 1973, no detailed information concerning this facility is available at present. Furthermore Manitoba Hydro has not expressed any intention regarding possible airstrips at Notigi, South Bay or any other control structure location to service these construction sites. As a result of this uncertainty and lack of information no attempt is made to determine the possible implications of Hydro development on these facilities.

C. Effect of Hydro Development on Resource Traffic

This section of the report examines the existing resources in the Southern Indian Lake--Rat-Burntwood Diversion study area and their present methods of removal as well as the implications to these removal methods of Hydro development. The potential resource base traffic will also be briefly discussed.

(1) Commercial Fisheries: Southern Indian Lake and its surrounding lakes form one of the most important commercial fisheries in Manitoba with an average annual catch of approximately 1,000,000 pounds, combined summer and winter.[2] The majority of the catch is whitefish (over 85 per cent) with

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[1] Information received from the Study Board.

[2] Based on figures obtained from the Manitoba Department of Co-operative Development: 1970--758,310 pounds, 1971--1,108,164 pounds, 1972--990,327 pounds.

pickerel, pike and trout also included in the total catch.[1] Table V lists all lakes included in the Southern Indian Lake Co-operative Fisheries Limited operations.

The fish processing plant for the Co-operative is located at Leaf Rapids. Fish caught on Southern Indian Lake and its surrounding lakes in summer (Table V) are brought to one of four collection stations on Southern Indian Lake or directly to Leaf Rapids in the case of certain lakes. Table V also indicates the collection station associated with each lake. The winter fishery is exclusively on Southern Indian Lake with Loon Narrows being used as the collection point.

Fish caught in summer in the case of outlying lakes are iced at the lake on which they are caught and transported to the various collection stations (or Leaf Rapids) by air. From the collection stations on Southern Indian Lake the fish are transported by refrigerated boat to the processing plant at Leaf Rapids. Fish caught in winter are transported from the collection point at Loon Narrows by air to Leaf Rapids for processing.

Processed fish are presently transported by truck from Leaf Rapids to Lynn Lake and thence by rail to Winnipeg. It is anticipated that, with the completion of Provincial Road 391 as far as Leaf Rapids, fish will be trucked directly to Winnipeg via Provincial Road 391 and Provincial Trunk Highway 6.

The planned increase in the level of Southern Indian Lake by Manitoba Hydro may alter the location of the existing fishing grounds. However, specific information regarding the possible changes in fishing areas on the Lake is not available at this time. One may anticipate that, with possible

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[1] Ibid.

TABLE V

SOUTH INDIAN LAKE CO-OPERATIVE COMMERCIAL FISHERY[1]

LAKE	COLLECTION STATION	SEASONALITY
Southern Indian	Loon Narrows	Summer & Winter
	Camp Nine	Summer
	Camp Three	↓
	Opachuanau	
North Knife	North End	
Etawney	↓	
Buckland		
Small		
Wood		
Northern Indian		
Little San		
Chipewyan		
Otter		
Loon		
Trout		
Moss		
Big Sand		
Denison		
MacKerracher		
Partridge Brest	Loon Narrows	
Thorsteinson	↓	
Fidler		
Gauer		
Chapman		
Torrance		
Cousins	Camp Nine	
Uhlman	↓	
Baldock		
Grandmother	Opachuanau	
Barlow	"	
Barrington	Leaf Rapids	
Eden	↓	
Costello		
Suwannee		
Karsakuwigamak		
Pemichigamau		
Mynsarski		
Rat		
Granville		

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[1] Manitoba Department of Co-operative Development.

alterations in the fishing grounds will come changes in the internal navigation patterns of the fishermen. Possible inundation and/or partial inundation of islands in the Lake may cause navigational difficulties for both fishermen and the fish collection boats. Flooding of shoreline tree stands may impair the accessibility to fishing areas which lie close to the shore of the Lake. However, information concerning these possibilities is unavailable at this time.

Commercial fishing operation by members of the Co-operative on the lakes forming a part of the Rat River (Karsakuwigamak, Pemichigamau and Rat Lake) may undergo alterations as a result of Hydro development. However the specific implications to transportation are difficult to assess since detailed information as to the exact effect of regulation on the fisheries in these lakes is unavailable at this time.

(2) Forestry: Present forestry operations in the study area are reported to be restricted to the need for building materials and fuel for residents of the various communities.

Churchill Forest Industries of The Pas holds a license to cut any merchantable timber in the study area. However, at present, no operations of this nature exist.

The potential merchantable timber in the study area lies south of Southern Indian Lake and along the Rat-Burntwood Diversion route.[1] No detailed information is available regarding the exact nature of this potential. However 25,000 to 35,000 cords per year have been estimated as possible yield in this area.[2]

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[1] Forestry Branch, Department of Mines, Resources and Environmental Management.

[2] Ibid.

The present implications of Hydro development to transportation of forestry products is negligible. However if the potential merchantable timber in the area is to be harvested in future, two basic questions should be asked:

1) How will Manitoba Hydro provide access to their construction sites at Manasan, Wuskwatim and Notigi and could this access be used to harvest timber in future?

2) What plans are there, if any, for establishment of a second forest products complex in Northern Manitoba? If this operation is established, what will be its location with respect to the study area?

The answers to these questions will have a great bearing on the future transportation needs of the forest products industry in the study area.

(3) Mining and Mineral Potential: Mining is an important resource industry in the Rat-Burntwood Diversion section of the study area. Both the community of Leaf Rapids and the City of Thompson were virtually wilderness fifteen years ago. However the discovery of nickel in the area of Thompson by Inco in 1957 and at Ruttan Lake (fifteen miles east of Leaf Rapids) by Sherritt-Gordon in the late 1960's resulted in the establishment of both Thompson and Leaf Rapids as important mining centers in Northern Manitoba.

With regard to the implications of Hydro development on these mining operations, it is unlikely that either the Ruttan Lake or the Thompson facilities will be adversely affected. The mine at Ruttan Lake is situated several miles from the forebay which will be created by diversion of the Churchill River, and as such should be unaffected. Similarly the mining operations near Thompson are located south of the city and therefore beyond the area to be inundated by the Manasan control structure.

Potential mining operations in the study area are dependent upon the economic viability of any ore body which may be brought into production.

Information concerning specific areas of potential mineral reserves is not available at this time. Therefore the effect of Hydro development on the transportation requirements of any potential mining operations cannot be ascertained.

(4) Fur Trapping: In the study area, the major fur trapping operations are centered on South Indian Lake and Nelson House. The value of furs to the trapper is subject to market demand fluctuations for the product and as such no representative average figure for the value of the furs in each of the above areas is available. Figures available for the 1970-71 fur trapping season indicate a total value to the trappers of $32,714.06 for furs collected at South Indian Lake and $36,774.13 for furs collected at Nelson House.[1]

Furs collected at South Indian Lake are removed by air to Lynn Lake and thence by rail to Winnipeg or are flown directly to Winnipeg.[2] Furs brought to Nelson House are flown to Thompson and from this point are taken by rail to Winnipeg or are flown directly to Winnipeg.[3]

It is unlikely that Hydro development will affect the existing methods of removing furs from the above two collection points unless the air facilities in these areas are adversely affected (see section IVB (5) on seaplane bases and IVB (6) on airstrips).

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[1] Manitoba Department of Mines, Resources and Environmental Management.

[2] Hudson's Bay Company, Northern Stores.

[3] Ibid.

D. Hydro Implications to Recreational Area Access[1]

In the study area, the important characteristics which determine recreational potential include: certain scenic features proximity to population centers and road accessibility.

Certain sections of the study area have been identified as having possible recreation potential within the framework established by the above factors.[2] These areas include:

a) The Burntwood River from Manasan Falls to the first set of falls below Thompson.

The factors which make this area attractive for recreation are its scenic qualities and its proximity to Thompson.

Any roads which may be provided to Hydro construction sites at Manasan and First Rapids (which form the extreme boundaries of this recreation area) could also be available for accessibility to this potential recreation area post regulation.

b) The Rat River below Notigi Lake to the north end of Wapisu Lake.

The area is attractive to recreational potential due to its proximity to Nelson House, its shoreline characteristics, water body characteristics, backshore landforms, vegetative cover, shoreline accessibility, scenic variety and aesthetic appeal.

Accessibility to this area could be provided by Provincial Road 391 and any Hydro-initiated road access associated with the Notigi dam site.

Other potential recreation areas may exist in the study area. However specific information regarding the location of such sites is unavailable at this time.

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[1] Department of Tourism, Recreation and Cultural Affairs, Parks Branch, is the source of the information in this section.

[2] Parks Branch, Department of Tourism, Recreation and Cultural Affairs.

E. Effect of Hydro Development on Transportation Services to the Communities

(1) Air Service: The study area communities (Thompson, Nelson House, South Indian Lake and Leaf Rapids) are all served by air on a scheduled and/or a charter basis. This service involves both passenger and freight movement. Table VI details the scheduled air service provided to all communities in the study area while Map VI illustrates the routes taken by the various scheduled carriers. If an airstrip in any community in the study area used by the carriers is adversely affected by the Hydro development there will be a correspondingly affect on the air service to the community in question. However, improvements to existing airstrips or construction of new facilities which may result from the increased activity caused by Hydro construction could provide an initial stage in overall improvement to air service in the area.

TABLE VI

SCHEDULED AIR SERVICE IN THE SOUTHERN
INDIAN LAKE--RAT-BURNTWOOD DIVERSION
STUDY AREA

CARRIER	CLASS OF LICENSE	BASE	POINT SERVED FROM BASE	FREQUENCY OF SERVICE (days per week)
Calm Air	3	Lynn Lake	Leaf Rapids	6
	3	Lynn Lake	South Indian Lake	6
	3	Lynn Lake	Thompson	6
	3	Lynn Lake	Missi Falls	Irregular
Ilford-Riverton	3	Thompson	Missi Falls	Irregular
Transair	1	Winnipeg	Thompson	7
Lambair	3	Thompson	Nelson House	6

(2) Road and Rail Service:[1] The study area communities which presently have all-weather road access to the rest of the province include Nelson House and Thompson. With the completion of the Thompson-Lynn Lake road (Provincial Road 391) Leaf Rapids will also be connected to the provincial highway network. The completion of this highway will initiate the movement of both people and freight by all-weather road in this area whereas previously only winter roads could provide this service. The community of South Indian Lake will not be accessible by all-weather road to the provincial highway network and will have to rely on a winter road to provide surface accessibility. However the completion of the Ruttan Lake-South Bay Hydro access road by the fall of 1973 (to about ten miles from South Indian Lake community) may provide the initial link in an eventual all-weather road to South Indian Lake.

Direct accessibility by rail is only provided to the community of Thompson in the study area (section IVB (4)). However, indirect access is also provided by the Lynn Lake section of the Canadian National Railway (Map V). Both passengers and freight wishing to enter the communities of Leaf Rapids and South Indian Lake by road (either all-weather or winter) must initially travel by rail to Lynn Lake at the present time. Completion of the Thompson-Lynn Lake road, however, will enable the communities to be served entirely by road (all-weather or winter) as discussed above.

F. Conclusions

As a result of the preceding discussion, several conclusions may be drawn regarding the implications to transportation and navigation in the Southern Indian Lake--Rat-Burntwood study area:

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[1] For further discussion of the road system see Sections IVB(1) and IVB(2).

(a) A portion of Provincial Road 391 north of Thompson will be flooded by the reservoir created by the Manasan dam (see section IVB(1d).

(b) The creation of forebays at Notigi and Wuskwatim may also result in a certain amount of flooding of Provincial Road 391 in the areas of Notigi dam site and Nelson House. A more detailed examination of these specific areas may be warranted.

(c) The extension of the Ruttan Lake road to South Bay may provide the initial link in an all-weather road connection to South Indian Lake. This conclusion is based on the premise that the Ruttan Lake-South Bay road will not be rendered unusuable post regulation due to flooding (see section IVB(1d)).

(d) The great portion of the present winter road network should not be adversely affected by Hydro development due to its overland routing. The exception to this is the section of winter road which crosses South Bay (part of the South Bay-Missi Falls winter road) and which may be affected by alterations in ice formation post regulation (see section IVB 2).

(e) The shallow stretch of water between Opachuanau Lake and Leaf Rapids may be rendered more easily navigable due to increased depth caused by regulation of Southern Indian Lake (see section IVB(4a)).

(f) The increased water levels on Southern Indian Lake post regulation may result in total or partial flooding of many islands, possibly necessitating a program for identification and marking, as an aid to navigation (see section IVB (4a)).

(g) Shoreline accessibility may be impaired after regulation due to flooding of tree stands along the shore of Southern Indian Lake (see section IVB (4a)).

(h) The seaplane base at Thompson may be affected by the increased velocity and accompanying turbulence in the Burntwood River as a result of the diversion of the Churchill River. Similar conditions may apply to the seaplane bases at Nelson House and South Indian Lake (see section IVB (5a)).

(i) Unless the dyking program recommended in the Galay-Baracos report on the Burntwood River is undertaken, the southern section of the Thompson airstrip could be flooded (see section IVB (6a)).

(j) Definite conclusions with respect to the effects of Hydro development on present and potential resource product traffic in the study area cannot be drawn without a more detailed analysis of the entire subject.

V LOWER CHURCHILL RIVER STUDY AREA

A. Major Features of Hydro Development and Immediate Physical Implications

Missi Falls: The erection of a control structure at the outflow of Southern Indian Lake at a site known as Missi Falls is scheduled for completion in 1974. The estimated cost of this dam is in the order of $38 million. At present no construction activity has been initiated, however, some of the materials to be used in the project have already been transported to the site.

By building a control structure at Missi Falls the main flow of the Churchill River (i.e. 30,000 cfs) would be diverted through a man-made channel into the Rat River and thence via the Burntwood River into the Nelson River at Split Lake. The Missi Falls structure will cause the water level of Southern Indian Lake, upstream from the dam, to be raised by approximately ten feet above the natural level. A minimum of 500 cfs will be released from Missi Falls into the lower Churchill River during open water periods, accounting for a substantial reduction in depth. A minimum flow of 1,500 cfs will be released during ice cover periods (section IVA 1).

B. Effects of Hydro Development on the Transportation Infrastructure

This section of the report investigates the possible effects of Hydro development on the existing transportation infrastructure of the Lower Churchill study area. Infrastructure is divided into six categories: all-weather roads, winter roads, railways, navigation, seaplane bases and airstrips. The physical effects on the existing transportation system as well as possible modifications resulting from Hydro development are considered for each type of infrastructure. For the purpose of this discussion the transportation system situated entirely within the town site of Churchill will be considered separately under section VD.

(1) All-Weather Roads: There are no existing all-weather regional roads in the Lower Churchill study area. The construction site of the Missi Falls dam will have a network of local roads to allow for internal access. Since the site development at Missi Falls is planned with the post regulation period in mind it is unlikely that any roads built by Hydro will be adversely affected by regulation.

(2) Winter Roads: Manitoba Hydro is currently constructing a winter road between South Bay and Missi Falls (see section IVB 2), which is scheduled for completion in early March, 1973 and will be open until break-up of 1973 (Map V). This road will be used to move supplies to the Missi Falls construction site during the current winter. In the past (during 1968-69) Hydro has moved these supplies by winter road originating at Thompson. However, with the construction of the South Bay access road (see section IVB 1c) and South Bay winter road extension, only the northern portion of the Thompson-Missi Falls route will be used. Excluding these winter roads associated with construction at Missi Falls there are no other winter roads in the Lower Churchill area.

In the immediate vicinity of the Missi Falls control structure, Hydro development is not expected to affect the winter access roads. The reduced current at the outflow of Southern Indian Lake because of the Missi Falls control structure may facilitate the formation of ice immediately upstream from Missi Falls and on the Lower Churchill. Consequently it is expected that crossing of the river in winter will be improved as a result of Hydro development.

(3) Railways: The Hudson Bay Branch of the Canadian National Railways (known as the Hudson Bay Railway) enters the Lower Churchill area at Chesnaye approximately forty miles south of the townsite of Churchill (Map VIII).

This line was built to serve as the inland access for the Port of Churchill for the shipment primarily of grain.

This Hudson Bay line does not come close to the channel of the Lower Churchill River. At its closest point near Tydal (immediately south of the townsite of Churchill) the line comes within two miles of the river. Should the diversion scheme cause any bank instability on the Lower Churchill it is unlikely that this development will adversely affect the railway embankment.

(4) Navigation: Other than the Port of Churchill which is treated separately in this section, the only navigation currently taking place in the area is that associated with providing access to the Missi Falls construction site. Water access to Missi Falls will be provided by a barge service (two barges with 200 ton capacity) from Leaf Rapids. A wharf at Missi Falls has been built to serve as an unloading point for construction materials.

The navigational consequences of Hydro development described earlier in the section dealing with water movement on Southern Indian Lake (section IVB 4a) also apply to water access to Missi Falls. The wharf at Missi Falls, since it has been built by Hydro to service the construction site, is not expected to be affected by high water levels on Southern Indian Lake.

As a result of Hydro development the lower 220 miles of the Churchill River will be drained during the summer months (excluding the 500 cfs released at Missi Falls). Available information indicates that no navigation for commerical purposes on this stretch of water presently occurs therefore no affect on this activity is anticipated.

(5) Seaplane Landing Bases: Air transport service to the Missi Falls control structure will be provided by float equipped aircraft until the Fall of 1973.

Since the seaplane base will not be operational after this period there will be no effect from Hydro development on this service.

(6) Airstrips: A major airstrip is planned for completion at Missi Falls by early Fall of 1973. Wheeled air service will replace the service currently provided by float equipped aircraft.

On the basis of available information, no effect as a result of Hydro development is anticipated on the airstrip to be built at Missi Falls.

C. Effects of Hydro Development on Resources and Transportation Implications

(1) Types of Resource: Except for a small band of conifers immediately south of Southern Indian Lake, the forest zone adjacent to the Lower Churchill is primarily transitional from forest to tundra.[1] In view of severe climatic and terrain characteristics it is unlikely that forestry will ever form a part of the resource inventory of this area.

At present no commercial fishing is taking place in the Lower Churchill study area other than on the lakes adjacent to Southern Indian Lake (as mentioned in section IV C1) which are tied to the Southern Indian Lake drainage area and transportation system.

Mineral resource potential in the Lower Churchill area has not been identified at present. Realization of any mineral development may follow future detailed surveys in the area.

The Parks Branch of the Department of Recreation, Tourism and Cultural Affairs has not identified any specific sites on the Lower Churchill as prime recreation areas. However the banks of the Churchill River are presently being used as the nesting grounds of a variety of geese. The significance of this area for wildlife conservation and any related passive recreational activity may be worth assessing, especially in view of expected deleterious effects from Hydro development.

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[1] Province of Manitoba, Royal Commission Inquiry into Northern Transportation, 1969.

(2) Transportation Implications: The implications of Hydro development to transportation as related to forestry, fishing and potential mining operations in the Lower Churchill area are expected to be minimal or non-existent.

The impact of Hydro development on transportation as an access to recreation areas in the region is difficult to assess. The nature of the overall impact will depend on certain questions. What use, if any, will be made of the airstrip at Missi Falls as a fly in point for tourists? What continuing effect will the diversion have on the nesting grounds of the Canada geese, etc.?

D. The Townsite of Churchill

This section of the report assesses the possible effects of Hydro development on the transportation infrastructure in the Townsite of Churchill. For the purpose of this report the Townsite of Churchill is treated as a separate entity from the Port facility, which is investigated in the next section.

(1) All-Weather Roads: Churchill has an elaborate network of local roads linking the four distinct areas which comprise the town: Fort Churchill, Dene Village, Akudlik and the townsite proper.

The roads are aligned far enough from the Churchill River embankment so as not to be affected by reduced flows in the channel.

(2) Winter Roads: At present there is no bridgehead across the Churchill River, connecting the town on one side of the river with historic Fort Prince of Wales (National Historic Site) on the other side. In winter, crossing is possible by bombardier across the ice. Essentially this short

trail is the only winter road in the area.

The diversion of the Churchill River is not expected to adversely affect this operation.

(3) Railways: (see section VB 3).

(4) Navigation: There is at present no navigation from Churchill inland. The only issue concerning navigation is related to the Port facility and is discussed in section VE.

(5) Seaplane Landing Bases: There is one seaplane base in the Churchill area at Farnworth Lake. This base is located south of the town at Lat. 58°42'N, Long. 94°03'W and is operated by Lambair Limited from July 1st to September 30th. Farnworth Lake is very shallow and it is possible to touch rocky bottom even at some distance from the shore. Numerous submerged rocks make landing hazardous.

Since Farnworth Lake is not tied to the Churchill River it is unlikely reduction in flow in the river would affect lake depths. It is also unlikely that a reduction in water table will take place since Farnworth Lake is situated at a considerable distance (five miles) from the river channel and drainage is in the direction of Hudson Bay.

(6) Airstrips: The airstrip at Churchill consists of two approach strips (asphalt, 9,200 feet and gravel, 6,081 feet) and is located at Lat. 58°45'N, Long. 94°04'W. The elevation of the strip is ninety-four feet. It is operated by the Ministry of Transport and is fully equipped for instrument landing.

This facility is not affected in any way by Hydro development because of its distance from the Churchill River channel.

(7) Inter-Community Infrastructure: Any modification to the existing pattern of transportation as it relates to the Townsite of Churchill and the rest of the province as a result of Hydro development (such as extension

of Hydro initiated access roads) is difficult to assess at this point. Any possible improvement in infrastructure initiated by Hydro construction is most likely to be associated with present and planned Hydro projects on the Lower Nelson River (beyond the terms of reference of this report) and not with the Churchill River diversion. Therefore, the nature of expected changes in accessibility to the Townsite of Churchill as a result of Hydro development is not discussed in this report.

E. The Port of Churchill

(1) Logistics of Support: Although its growth has been stifled throughout its forty-two year history, the Port of Churchill remains an integral part of the transportation system of the Prairies and the eastern Arctic regions. The chief advantage of the Port of Churchill and the Hudson Bay Route to farmers and business men on the Prairies is shorter rail haul from Churchill to Prairie points of origin (or destination) as compared to the St. Lawrence Ports. An example of mileage comparisons between Saskatoon in the center of the Canadian Wheat Belt and Liverpool, England is as follows:

Saskatoon-Thunder Bay by rail	900 miles
Thunder Bay-Montreal by lake vessel	1100 miles
Montreal-Liverpool by ocean vessel	2900 miles
TOTAL	4900 miles
Saskatoon-Churchill by rail	800 miles
Churchill-Liverpool by ocean vessel	3000 miles
TOTAL	3800 miles

The overall reduction of 1100 miles via Port Churchill includes a saving of 100 miles of rail haul, a form of transport normally twenty to thirty times more expensive than water transport.[1] A second advantage of the Port of Churchill over other shipping routes for exports and imports to and from Europe is related to the capacity for traffic growth on the Hudson Bay Route. All other shipping routes which could be economically used by Prairie importers and exporters are already operating at near capacity. Only in its fourteenth year of operation, the St. Lawrence Seaway may have to undergo expansion of its lock system to accomodate forecast traffic in the next ten years. Shipping Vancouver to Europe necessitates navigating the Panama Canal which has reached such extreme proportions of crowding that preliminary plans for a second "sea level" canal are already underway. Use of the Atlantic ports necessitates long rail hauls which makes this method uneconomical as an alternative for shipments to and from the Prairies. The purpose of the discussion at this stage has been to establish the logistics of support for the Hudson Bay facility to provide a basis for the analysis that follows.

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[1] Hudson Bay Route Association, Ice Conditions and other Factors Related to the Opening and Closing of Navigation on the Hudson Bay Route, Annual Meeting, Prince Albert, Saskatchewan, February, 1949.

(2) Traffic Through the Port: The Port of Churchill throughout its history has functioned primarily as a shipment point for wheat from Saskatchewan to Western Europe (see Graph I). According to the National Harbours Board:

> "Exports of commodities other than wheat (in 1971 about 5 million bushels of barley were shipped out of Churchill for the first time) have been very negligible. Foreign inward traffic has also been very minute compared to wheat exports and in fact petroleum products alone constituted some 89% of total inward movement (2500 tons in 1971) comprised of miscellaneous commodies such as alcoholic beverages (500 tons), industrial machinery, pipes and tubes."[1]

Tables VII, VIII, IX and X indicate the nature and volume of traffic through the Port of Churchill for a twenty-one year period (1950-71).

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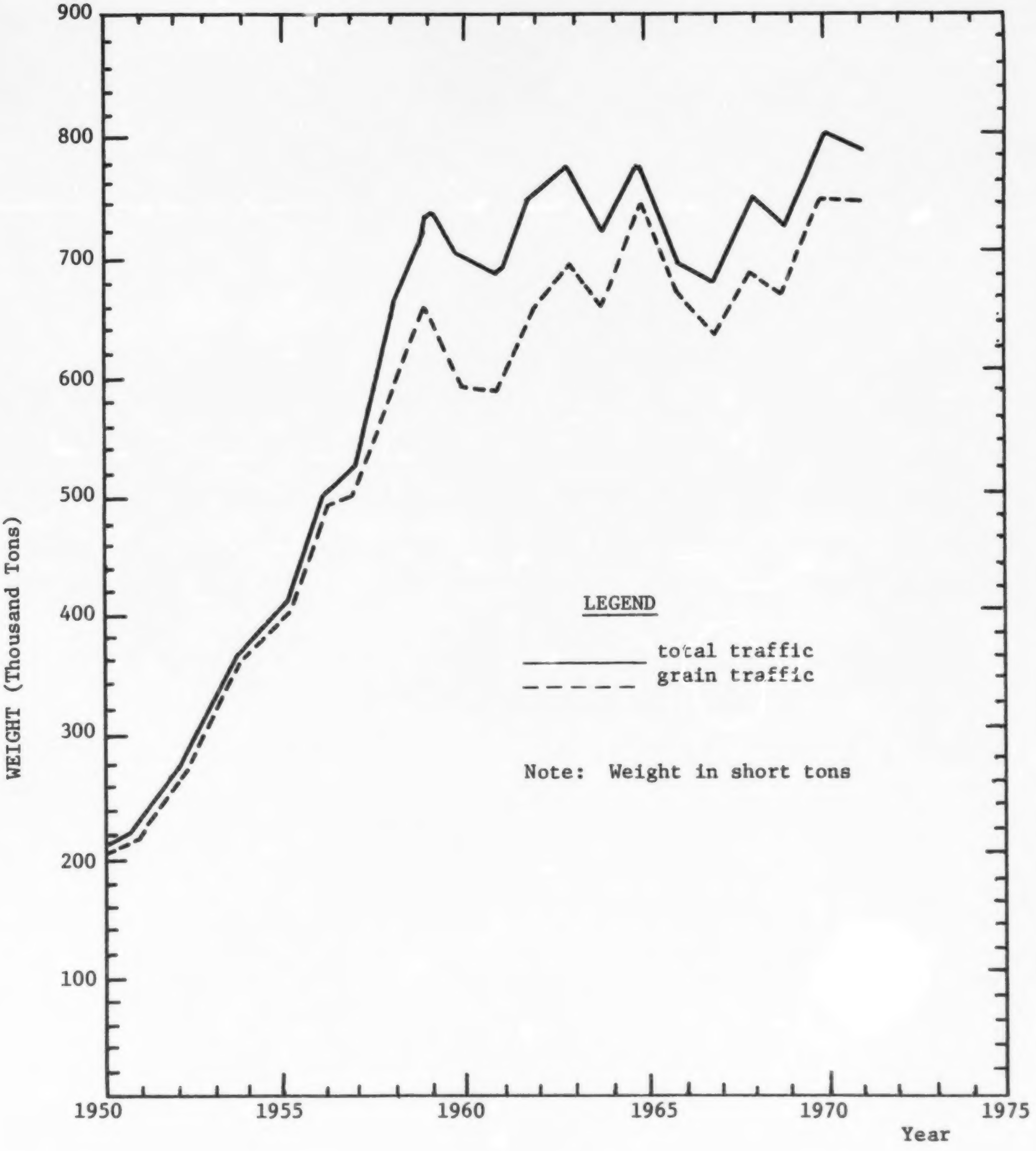
[1] National Harbours Board, "Churchill: Canada's National Harbour of the North," Ottawa, 1971.

GRAPH I

GRAIN TRAFFIC--TOTAL TRAFFIC
FOREIGN AND DOMESTIC--INWARD AND OUTWARD



Source: National Harbours Board

TABLE VII

PORT OF CHURCHILL
DOMESTIC TRAFFIC - INWARD
(Short Tons)

YEAR	TOTAL
1971	97
1970	250
1969	258
1968	199
1967	467
1966	115
1965	369
1964	813
1963	187
1962	12,803 (Ores and concentrates)
1961	17,705 (Ores and concentrates)
1960	21,446 (Ores and concentrates)
1959	22,230 (Ores and concentrates)
1958	21,570 (Ores and concentrates)
1957	180
1956	232
1955	3,581 (Fuel oil)
1954	317
1953	290
1952	762
1951	172
1950	11

National Harbours Board

TABLE VIII

PORT OF CHURCHILL
DOMESTIC TRAFFIC - OUTWARD
(Short Tons)

YEAR	GRAIN	PETROLEUM PRODUCTS	MISCELLANEOUS	TOTAL
1971	9,055	14,256	3,903	27,214
1970	9,133	13,070	2,630	24,833
1969	8,726	12,246	2,471	
1968	9,009	16,158	3,231	28,398
1967	11,924	15,147	2,218	29,289
1966	8,324	6,200	2,914	17,438
1965	5,025	11,106	1,524	17,655
1964	3,744	22,131	1,326	27,179
1963	7,258	18,792	1,333	27,383
1962	6,738	14,400	1,712	22,850
1961	6,103	15,085	1,861	23,049
1960	2,576	9,852	3,097	15,525
1959	3,010	11,220	1,765	15,995
1958	4,875	4,608	1,992	11,475
1957	3,625	453	2,164	6,242
1956	4,490	1,077	3,889	9,456
1955	2,200	1,679	3,249	7,128
1954	-	1,013	1,699	2,712
1953	-	1,352	1,877	3,229
1952	-	1,581	1,955	3,536
1951	-	690	1,865	2,555
1950	-	857	1,458	2,315

National Harbours Board

TABLE IX

PORT OF CHURCHILL
FOREIGN TRAFFIC - INWARD
(Short Tons)

YEAR	PETROLEUM PRODUCTS	MISCELLANEOUS	TOTAL
1971	19,827	2,469	22,296
1970	34,782	2,045	36,827
1969	32,846	6,786	39,632
1968	37,932	6,781	44,713
1967	19,731	4,841	24,572
1966	16,658	3,634	20,292
1965	18,075	1,794	19,869
1964	36,272	1,596	37,868
1963	49,206	1,703	50,909
1962	50,070	3,309	53,379
1961	48,892	2,915	51,087
1960	68,961	4,805	73,766
1959	36,803	5,766	42,569
1958	30,314	3,107	33,421
1957	16,486	4,557	21,043
1956	-	2,589	2,589
1955	-	4,161	4,161
1954	-	4,622	4,622
1953	-	2,972	2,972
1952	-	8,529	8,529
1951	-	7,650	7,650
1950	-	3,350	3,350

National Harbours Board

TABLE X

PORT OF CHURCHILL
FOREIGN TRAFFIC - OUTWARD
(Short Tons)

YEAR	GRAIN	MISCELLANEOUS	TOTAL
1971	735,157	7,907	743,064
1970	738,410	3,791	742,201
1969	656,189	522	656,711
1968	675,495	3,498	678,993
1967	619,174	5,430	624,604
1966	654,520	1,048	655,568
1965	741,210	1,145	742,355
1964	649,344	4,178	653,522
1963	685,932	14,054 (1)	699,986
1962	645,756	15,175 (2)	660,931
1961	580,576	9,550 (3)	590,126
1960	589,317	-	589,317
1959	655,991	-	655,991
1958	592,851	-	592,851
1957	498,280	-	498,280
1956	487,510	-	487,510
1955	392,334	3,345 (4)	395,679
1954	375,544	-	374,544
1953	323,533	-	323,533
1952	257,553	-	257,553
1951	218,353	-	218,353
1950	203,032	-	203,032

[1] Gasoline

[2] Sulphur, nickel, copper

[3] Ores and concentrates

[4] Wheat flour

National Harbours Board

The countries of Western Europe are the major destination points for wheat export ex-Churchill. The United Kingdom, Belgium, Luxembourg, West Germany, Netherlands and Norway have been consistent importers in the last ten years.[1] Table XI (A and B) indicates the destination points for wheat export ex-Churchill for the period 1962-71.

A small percentage of the cargo shipped through the Port of Churchill is destined for the settlements in the Eastern Arctic. The requirement in the Keewatin District settlements according to Commissioner S. M. Hodgson of the Government of the Northwest Territories has been in the range of ten thousand tons in the past three years (1970-72).[2] Of this, 70 to 80 percent have been petroleum products which for the most part have been shipped from Churchill. The remainder of the imports are shipped directly from Montreal. With respect to the future role of Churchill as a re-supply port for the Keewatin District, Premier Ed Schreyer has commented as follows:

> "It is obvious to anyone who examines the flow of re-supply goods to the N.W.T. that the Port of Churchill can gain a more significant portion of this trade if a marine shipping and forwarding operation were stationed at Churchill."[3]

Whether the Port of Churchill can play a more significant role in Arctic re-supply will depend on its ability to compete with Montreal as a distribution center. In the long term the Port of Churchill will also be affected by several related developments among which is the possible establishment of an Arctic port such as the Northport proposal by the Great Plains Project for the Chesterfield Inlet area.

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[1] Ibid.

[2] Compendium of Speeches and Articles presented at the Churchill Convention, Churchill, Manitoba, July, 1972.

[3] Ibid.

TABLE XIA

PORT OF CHURCHILL
DESTINATION OF EXPORT WHEAT--1962-1966
(Short Tons)

COUNTRY	1962	1963	1964	1965	1966
United Kingdom	424,637	456,870	367,166	435,367	343,308
Belgium and Luxembourg	45,304	66,678	61,039	155,850	124,662
Germany Fed. Rep.	11,060	6,590	32,127	18,144	-
Ireland	-	-	11,575	12,071	11,256
Italy	-	-	13,608	15,764	-
Netherlands	81,328	74,172	58,968	53,720	59,351
Norway	47,048	31,888	48,034	47,266	37,408
Finland	-	-	-	-	-
Poland	-	-	43,990	-	39,786
France Med.	-	14,391	-	-	-
Malta and Gozo	13,496	-	-	-	-
Netherlands Antilles	17,864	-	-	-	-
Dominican Republic	-	-	12,732	-	-
USSR Europe	-	-	-	-	38,985
Cuba	-	-	-	-	-
Iraq	-	-	-	-	-
India	-	-	-	-	-
TOTAL	640,737	650,589	649,239	738,182	654,756

Source:

Statistics Canada--1962-1970
National Harbours Board--1971

TABLE XIB

PORT OF CHURCHILL
DESTINATION OF EXPORT WHEAT--1967-1971*
(Short Tons)

COUNTRY	1967	1968	1969	1970	1971*
United Kingdom	270,362	293,498	296,996	403,428	292,355
Belgium and Luxembourg	142,578	102,132	129,770	143,258	45,494
Germany Fed. Rep.	-	-	-	8,876	-
Ireland	-	-	-	-	-
Italy	-	-	108,902	27,104	45,650
Netherlands	53,392	173,048	98,208	48,468	89,428
Norway	35,844	-	18,256	64,422	23,431
Finland	-	-	-	-	-
Poland	40,303	38,864	-	-	-
France Med.	-	-	-	-	-
Malta and Gozo	-	-	-	-	-
Netherlands Antilles	-	-	-	-	-
Dominican Republic	-	-	-	-	-
USSR Europe	25,402	11,330	-	-	-
Cuba	51,794	45,862	-	42,584	-
Iraq	-	-	-	-	24,981
India	-	-	-	-	213,818
TOTAL	619,675	664,734	652,132	738,140	735,157

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*Includes 118,031 tons of barley shipped in 1971

Source: Statistics Canada--1962-1970
National Harbours Board-1971

It is difficult to hypothesize on the optimum use of the Port of Churchill. It is generally believed that considering the present port facilities with no extension to the navigation season the Port has a potential for handling 30 million bushels of grain in one season. Up to now the maximum grain shipments through the Port have been 25 million bushels in 1971.[1] The volume of other shipments through the Port has not shown any increase in the last ten years; they have remained relatively constant at about 5 to 10 per cent of the total shipments.

(3) Variables Limiting Further Use of the Facility: The factors limiting the growth of traffic through the Port of Churchill are many and varied. Some limiting factors may be corrected with a minimum amount of capital investment while others are seemingly insurmountable. Some factors act as single forces inhibiting growth, while others are a product of these forces which augment the total detrimental effect. To understand the variables limiting further use of the Port on Hudson Bay all negative factors should be considered as a system of inter-related forces. As a result any effect (detrimental or beneficial) which Hydro development has on any one factor may alter any number of other factors. To obtain a clear consensus of the total effect of Hydro development on the Port of Churchill each limiting factor must be considered separately and then as a part of the system.

a) Length of Season: The present navigation season at Churchill extends for an eighty-two day period from July 22 to October 15. A strict adherance to these dates is subject to ice conditions at the mouth of the Churchill River (the harbour area) and in Hudson Strait. The latest date for closing of the harbour is subject to the effects of slob or slush ice formed inland and carried downstream by the Churchill River. Slush ice is caused by fresh water in the Churchill River freezing in advance of the saline Bay waters. The slush ice collects in the harbour area blocking further movement of vessels in and out of the port (Map IX).

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[1] Winnipeg Free Press, July 29, 1972.

Some actual dates of harbour closing as a result of this condition are:

(Test period 1928-62).[1]

October 9	0% of the years
October 15	19% of the years
October 22	53% of the years
October 29	82% of the years
November 9	100% of the years

Slush ice conditions impair navigation through Hudson Strait in the same manner as at the Port. November 10th is considered to be the latest safe date for unescorted unstrengthened vessels to pass through the Straits. Since Hudson Bay is relatively ice free during this time, an approximate twenty-six day period exists (October 15--November 9) between the closing of the Port of Churchill due to ice conditions in the harbour area, and the initiation of slush ice conditions in Hudson Straits.[2]

From this discussion it is important to note that should the slush ice problem in the harbour area be solved, the closing date of the navigation season on the Hudson Bay Route would be delayed an average of twenty-six days.[1]

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[1] Province of Manitoba: Royal Commission Inquiry into Northern Transportation, Winnipeg, 1969.

[2] Aerial surveys as early as the 1920's have shown that vast expanses of Hudson Bay never freeze up. In essence winter ice is formed locally along the shoreline in tiny bays about mid-November. By the end of this month the mouths of the rivers flowing in the Bay are frozen over. Hudson Bay Association, Ice Conditions and other Factors Related to the Opening and Closing of Navigation on the Hudson Bay Route, Annual Meeting, Prince Albert, Saskatchewan, February, 1949.

Other types of ice conditions affect the length of season.[2] Examples:

i) "Bergs and growlers" off Resolution Island at the entrance to Hudson Straits.

ii) Ice Advance through Foxe Channel.

iii) "Rafted ice" in the Bay area, etc.

However, since the purpose of this section of the report is to assess the possible effects of Hydro development on the operation of the Port of Churchill these other ice conditions are irrelevant at this time. The essential condition for the purpose of this study is to assess the effect of Hydro development on the slush ice problem at the mouth of the Churchill River.

The present flow on the Churchill River ranges from a low of 29,600 cfs during the fall and winter period (at Fiddler Lake) to a high of 50,000 cfs during the spring and summer period (at Fiddler Lake). During the month of October when slush ice at the mouth is a problem the approximate flow on the Churchill River is 39,000 cfs.[3]

As indicated in section IV A1, the present intention of Manitoba Hydro is to raise Southern Indian Lake about ten feet to a maximum elevation of

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[1] The "Royal Commission Inquiry into Northern Transportation" notes: "If an economical method were found to reduce or eliminate the problem of slush ice in the harbour it would be possible to extend the shipping season by about 23 days beyond the present limit of normal insurance (October 15th) and about 13 days beyond the average date on which the harbour is forced to close due to ice." The difference between 23 day and 26 day extension comes from using an average date or closing due to ice versus the final date of November 9th.

[2] op. cit., Hudson Bay Route Association, Annual Report, 1949.

[3] Water Resources Branch, Manitoba Department of Mines, Resources and Environmental Management, 1973. The values quoted are reconstructed historical values for the period 1930-1966.

850 feet. The increase in water level above natural conditions will be accomplished by substantially reducing the flow on the Churchill River downstream of Missi Falls. The end result is that 30,000 cfs will be diverted from the Churchill River into the Nelson River via the Rat-Burntwood system. Under the license given to Manitoba Hydro, a minimum of 500 cfs must be released from the Missi Falls control structure during open water periods and 1,500 cfs during ice cover periods. The unregulated catchment area below Southern Indian Lake is about 14,000 square miles. The estimated mean flow from this area is about 6,200 cfs.[1] During late summer, however, this figure is reduced considerably. At this time a figure of 5,000 cfs (including the 500 cfs released at Missi Falls) appears to be a reasonable estimate of the post regulation flow on the lower Churchill River as it enters the Churchill harbour. The post regulation figure is approximately 13 per cent of the natural unregulated flow (September to October).

In assessing the impact that the Churchill River diversion will have on the slush ice problem in the harbour area, two points of view should be noted. The former chairman of Manitoba Hydro, David Cass-Beggs reiterated in June, 1972 that:

> "...the diversion plan would reduce the flow of water on the lower Churchill, allow salt water to enter the harbor more freely and thus delay the formation of ice in the fall."[2]

The basis for this assumption would appear to be that reduced flow on the lower Churchill River will allow the water to freeze over much faster forming a solid sheet upstream of the harbour. The period during which slush ice is formed will be shortened and the volume of ice will be reduced considerably, mitigating the severity of the problem in the harbour area. Opposing this viewpoint is the possibility that the Churchill River will not freeze over forming a solid sheet. The 5,000 cfs estimated flow will be sufficient to keep the channel open and slush ice will still be carried into the harbour. Since the post regulation flow will be much less than the existing flow, rate of heat loss may be accelerated causing slush ice to form earlier in the year. In that eventuality the problem in the harbour would be aggravated.

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[1] Hedlin, Menzies and Associates Limited, Port of Churchill, Potential for Development, Volume II, Appendices, Winnipeg, January, 1969.

[2] Winnipeg Free Press, June 9, 1972.

b) Operational Limitations: A report by Sir Alexander Gibb and Partners to the "Committee on Manitoba's Economic Future" (1962) drew attention to the uneven arrivals of vessels and the effect upon Port congestion toward the end of the shipping season. According to the report the ideal rate of vessel arrivals at Churchill would be one per day. Assuming no additions to the existing facilities, as shown on Map X, and assuming an optimum spacing of ship arrivals, as many as seventy-nine vessels could be loaded from the two berths in an eighty day season without congestion.

The limiting factor in efficient Port operation is not the number of berths or the speed at which vessels are loaded once they are in their berths but rather the loading rate as influenced by uneven arrivals of ships combined with the strong wind, and currents which may delay berthing or departure.

The current trend to increased use of larger self-turning vessels should reduce the number of arrivals and associated congestion. In terms of operating cost alone, the time of vessel turn around is considered very important to an effective harbour operation. Reduction in turn around time may result in substantial savings to ship owners and charterers and subsequently encourage better utilization of the Port.

The present depths of various sections of the harbour impose constraints on the adoption of larger vessels. The depths in question are as follows:

Depth of loading berth	32'
Turning basin	
(over width of 600')	30'
(over width of 200')	24'
Shipping	
(minimum depth)	24'
Approach lane	
(minimum depth)	26'

The present constraints imposed by availability of depth compel larger vessels to leave the harbour during the two hours prior and subsequent to high tide. This results in increased congestion. An approach lane depth of thirty feet would not increase the laden draft of a vessel appreciably (four feet); however this increase would allow greater flexibility in timing the departure of larger vessels.

According to Del Taylor, Chairman of the National Harbours Board:

> "The present 32 foot depth of Churchill Harbour means it could accommodate 582 vessels operating throughout the world. If it were dragged (sic) to 35 feet some 400 more vessels could make use of it....
>
> Lowering the depth to a 40 foot level would result in a saving of five cents a bushel on shipping costs and to 50 feet 8 cents per bushel."[1]

This analysis has thus far considered depth requirements for more efficient operation of the Port facility. An obvious question which follows from this discussion is: What effect will Hydro development have on the various depths in the harbour area? Before this question is answered certain other questions must be asked:

1) What is the source of the suspended material deposited by the

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[1] Compendium of Speeches and Articles presented at the Churchill Convention, Churchill, Manitoba, July, 1972.

Churchill River at its mouth?

2) Will a substantial reduction in the existing flow on the Lower Churchill River reduce the rate of erosion along its banks and/or along the banks of its tributaries?

3) Assuming that the rate of erosion is unchanged will the reduced flow on the Lower Churchill River increase the volume of sediment deposited in the harbour area?

Depending on the answers to these questions, the diversion of the Churchill River will either cause an increase or a decrease in the amount of sedimentation in the harbour area. The accompanying increase or decrease in the cost of dredging operations to maintain a suitable channel depth would therefore be a direct result of Hydro development.

c) Other Limiting Factors: Any attempt to identify the total impact of Hydro development on the Port of Churchill, must consider other limiting factors which are not directly affected by the development but which may be modified as a result of effects to the two factors mentioned above, i.e. length of season and sedimentation. These will be discussed briefly.

i) Railway Freight Rates: High freight rates on the Hudson Bay branch of the Canadian National Railway are reported to have discouraged the movement of cargo through the Port of Churchill. According to the "Royal Commission Inquiry into Northern Transportation" (1969) the estimated rail freight incurred in exporting Canadian wheat to the United Kingdom from a mid-prairie point is:

13.20¢/bu. via Churchill
13.80¢/bu. via St. Lawrence (Montreal)
13.80¢/bu. via Thunder Bay

As noted previously Churchill enjoys a one hundred mile and 1,200 mile advantage in rail haul over Thunder Bay and Montreal respectively. The cost saving of 0.60¢ per bushel does not appear to reflect the distance advantage of the Hudson Bay facility.

There are essentially four reasons for the relatively high freight rates on the Hudson Bay line.

1) Low volume of traffic as a result of sporadic regional development and short season of operation at Churchill.

2) One way direction of traffic to the Port (see section V E2).

3) High railway maintenance cost with operating conditions below standard compared to southern east-west routes.

4) Technological improvements in commodity movement on southern operations (eg. containerization) have reduced the unit cost of transportation.

The first two reasons are related to the length of season on the Hudson Bay Route and to Port efficiency as affected by depth of harbour.

Extension of the navigation season for approximately twenty-six days resulting from the possible elimination of the slush ice problem in the harbour area may affect the volume and direction of traffic through the Port. This situation may be further encouraged by the increased availability of the harbour to vessels as a result of a possible reduction in sedimentation and increased depth. A favourable effect on the volume and direction of traffic through the Port may be reflected in reduced railway freight rates.

ii) Insurance Rates: The cost of insurance on ocean-going vessels consists of premiums for basic insurance (master hull policy) plus an additional premium for routes where there are additional hazards, such as the Hudson Bay Route, the Great Lakes, etc. While the master hull policy is applied on an annual basis, starting and terminating at an arbitrary date suitable to the ship owner, the additional premium applies to a single direct in-out voyage, the date of season when applicable being set by the underwriter.[1]

There is one rate for vessels using the Hudson Bay Route fixed in 1956; it applies to vessels not over fifteen years old, that do not pass Cape Chidly (eastern end of Hudson Strait) before July 23 and that leave Churchill on or before October 15. A vessel leaving Churchill between October 15 and October 20 is insured at a 20 per cent surcharge.[2]

Insurance underwriters negotiate with the owner of the cargo on a specific cargo rate independent of the rate assessed on the vessel. The cargo rates assessed on the Port of Churchill are considerably higher than rates assessed on other Canadian ports. Together with the hull rate they consist of 4 to 5 per cent of the forwarding cost of grain from the Prairies to Britain.

Insurance rates have the effect of both discourgaging traffic growth and of limiting the navigation season (to a short eighty-two day period) on the Hudson Bay Route. However, an extension of the navigation season, as a result of elimination of slush ice, from October 15 to November 9 would warrant a re-negotiation of the 20 per cent surcharge applied during this period. Increased accessibility of the harbour to vessels of drafts thirty-five feet and over, a possible result of reduced sedimentation and lower dredging costs, may affect the existing volume and direction of traffic through the Port of Churchill. This situation could conceivably encourage a reduction in master hull rates and cargo rates to users of the facility.

iii) Diversion Rates: Diversion rates are surcharges that the Canadian Wheat Board has had to pay elevator companies on shipments of wheat through the Port of Churchill. A "diversion rate" is basically an added insurance for Canadian grain companies on the possibility of having large stocks stored for eight or nine months at Churchill where they would be unavailable in the event of temporary favourable market conditions during the months in which Churchill is closed.[1]

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[1] op. cit., Royal Commission Inquiry into Northern Transportation.

[2] Ibid.

As was the case for railway freight rates and insurance premiums, diversion rates are affected by the volume and nature of traffic through the Port and most important by the length of navigation season on the Hudson Bay Route. Any modification to traffic flow and length of season initiated by the Churchill River diversion may affect the elevator company surcharges.

iv) Cleaning and Drying Facilities and Storage: The Royal Commission Inquiry into Northern Transportation notes:

> "Although, in recent years cleaning arrangements have been greatly improved, this remains the main bottleneck since most of the grain has to be cleaned two or three times to obtain the required standard."

Further improvements in grain cleaning facilities, together with a more efficient rate of vessel arrival as affected by depth of harbour would greatly alleviate Port congestion.

v) Political and Business Interests: Unlike the St. Lawrence Seaway Ports or the Pacific Ports, the Port of Churchill is not situated in an economically developed and densely populated region. Capital investment in the Northern facility is microscopic in relation to the capital invested in the Southern ports, particularly in recent years. As a result of a weak regional base and a weak financial voice the Port of Churchill has not encouraged strong favourable political action over the years.

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[1] Hudson Bay Route Association, Imports Via the Hudson Bay Route, 1948 Annual Convention, February, 1949.

Any improvement of this situation will be the result of numerous inter-related conditions and is difficult to assess. One can only suppose that as the economic stature of the facility improves (a result of the variables mentioned above) that the political and business interests will follow in due course.

4. Conclusions

As a result of this discussion several issues should be noted:

(a) The diversion of the Lower Churchill River may reduce or increase the volume of slush ice formed in the harbour area after October 15th (section 3(a)).

(b) The increase or decrease in the length of the navigation season at the Port of Churchill will directly affect the volume of traffic through the Port and may affect all the other variables presently limiting further use of the facility.

(c) The formation of slush ice in the harbour as possibly modified by the lower Churchill River diversion can only be understood after a detailed ice formation study is undertaken. The findings from this study would form the basis for an overall evaluation of the impact of Hydro development on the Port of Churchill.

(d) The diversion of the Lower Churchill River may reduce the volume of sedimentation presently taking place in the harbour area (section 3(b)).

(e) A possible reduction in the rate and volume of sedimentation may facilitate action to dredge the harbour to sufficient depths for larger draft vessels.

(f) Increased harbour depth and its effect on improving the availability of the facility to numerous ocean vessels now incapable of entering the thirty-two foot approach channel would also improve the efficiency of the

the Port so that more cargo will be loaded and unloaded per time available.

(g) The direct effect of reduced sedimentation and increased harbour depth on higher volumes of traffic may indirectly affect other variables acting in total to increase use of the facility.

(h) As was the case for the slush ice issue, the effect of the Lower Churchill River diversion on sedimentation and subsequent dredging costs can only be understood after a detailed study is undertaken. Again, the findings from this study would form the basis for an overall evaluation of the impact of Hydro development on the Port of Churchill.

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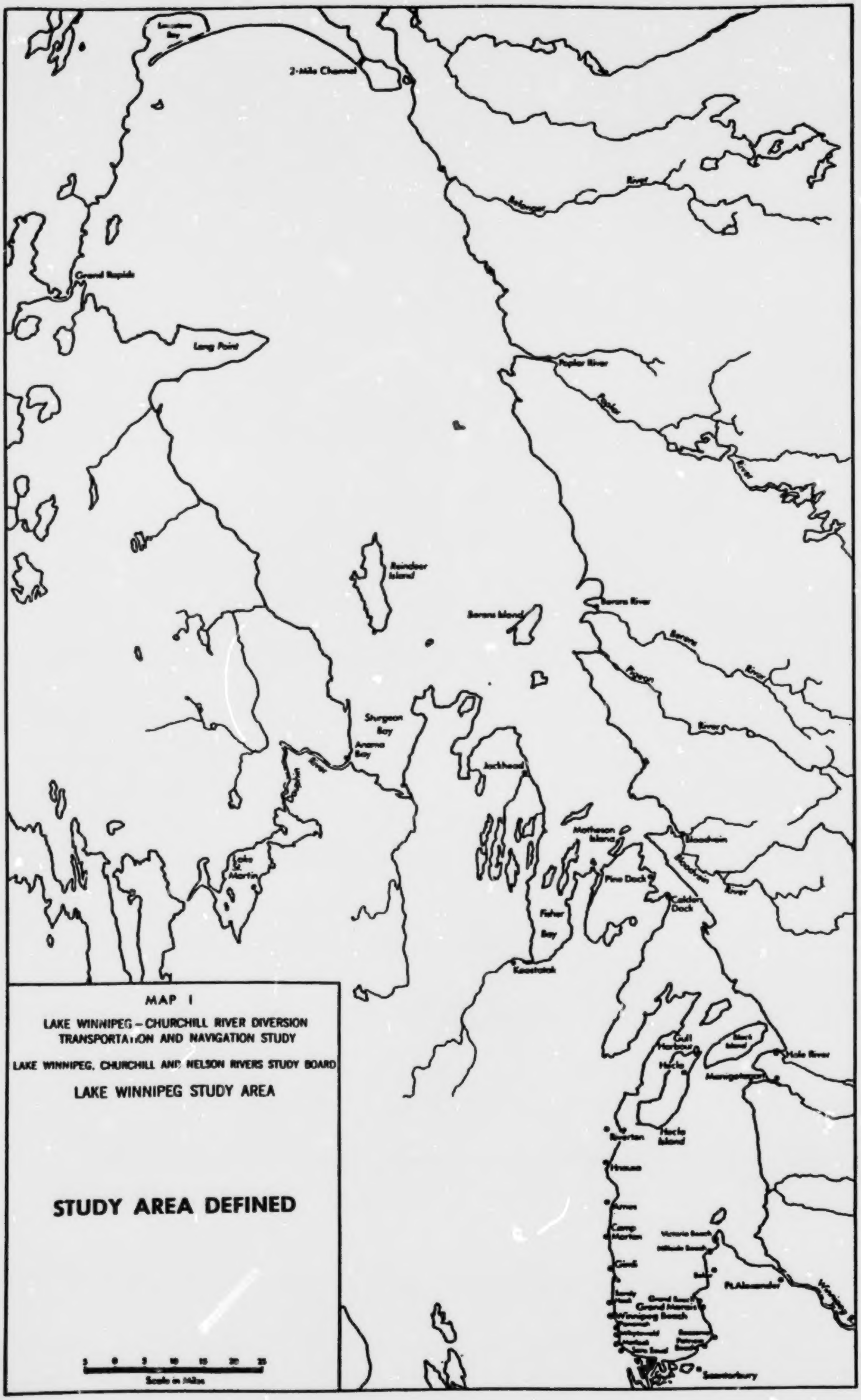
APPENDIX:
MAPS


Limestone Bay
2-Mile Channel
Belanger River
Grand Rapids
Long Point
Poplar River
Poplar River
Reindeer Island
Berens Island
Berens River
Berens River
Pigeon River
Sturgeon Bay
Anama Bay
Jackhead
Matheson Island
Pine Dock
Bloodvein
Bloodvein River
Calder Dock
Fisher Bay
Kaostatak
Lake St. Martin
Gull Harbour
Hecla
Black Island
Hole River
Manigotagan
Riverton
Hecla Island
Hnausa
Arnes
Camp Morton
Victoria Beach
Hillside Beach
Gimli
Pt. Alexander
Grand Beach
Grand Marais
Winnipeg Beach
Sans Souci
Scanterbury
5 0 5 10 15 20 25
Scale in Miles

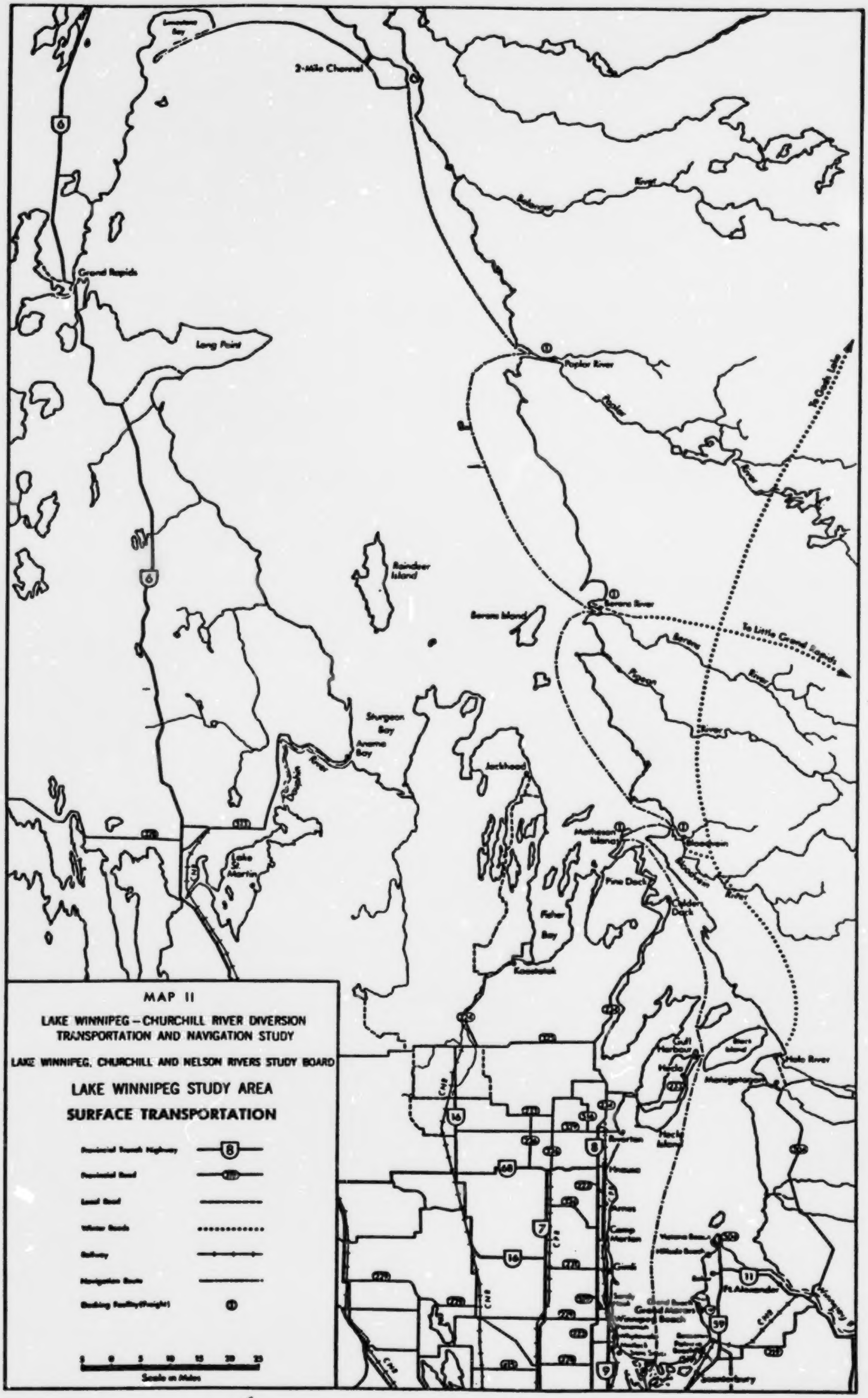
MAP I

LAKE WINNIPEG – CHURCHILL RIVER DIVERSION
TRANSPORTATION AND NAVIGATION STUDY

LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

LAKE WINNIPEG STUDY AREA

STUDY AREA DEFINED



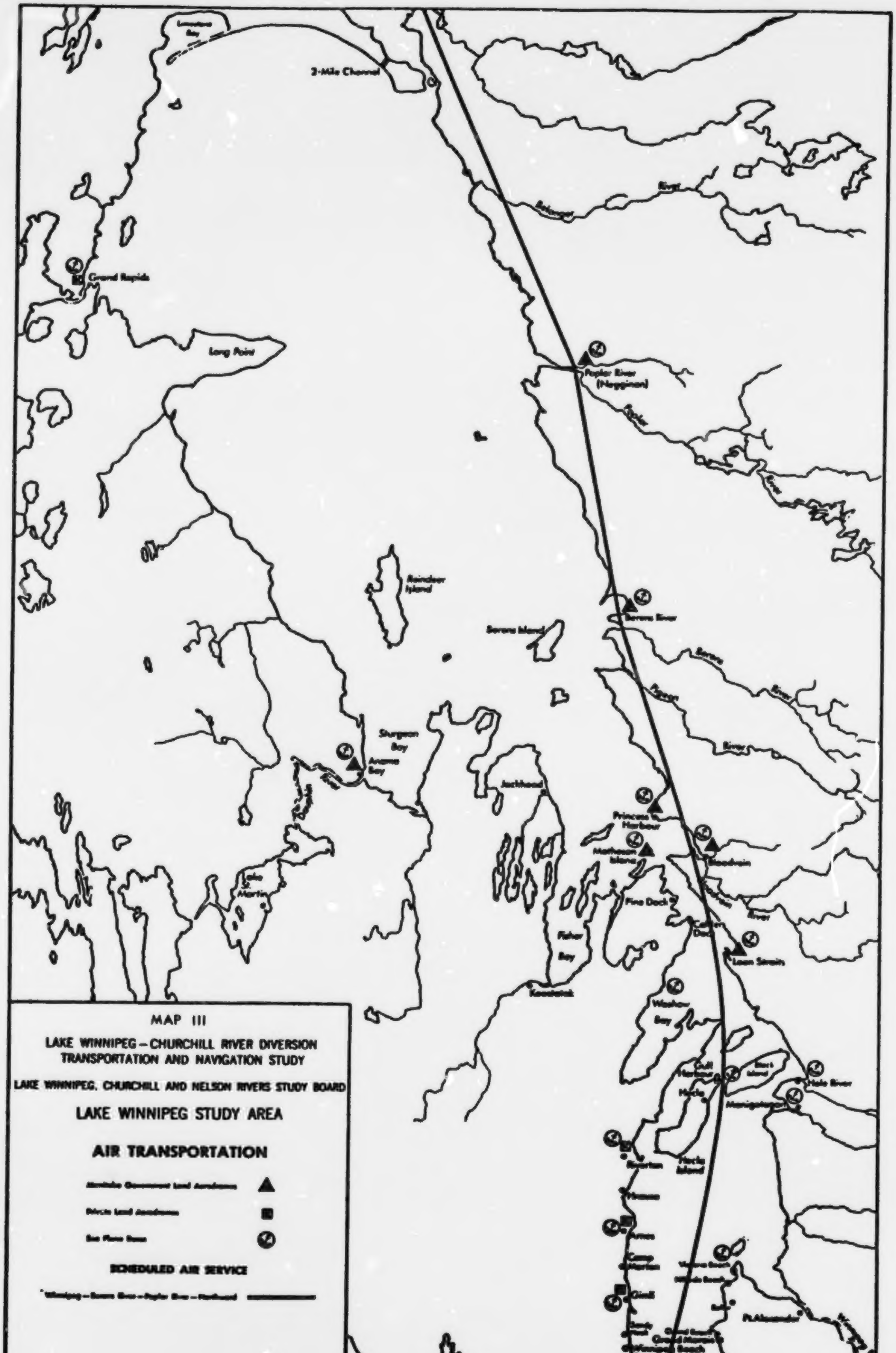
MAP 11

LAKE WINNIPEG – CHURCHILL RIVER DIVERSION
TRANSPORTATION AND NAVIGATION STUDY

LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

LAKE WINNIPEG STUDY AREA
SURFACE TRANSPORTATION

Provincial Trunk Highway
8
Provincial Road
Local Road
Winter Roads
Railway
Navigation Route
Docking Facility (Freight)
0 5 10 15 20 25
Scale in Miles
2-Mile Channel
Grand Rapids
Long Point
6
Poplar River
Poplar River
Reindeer Island
Berens Island
Berens River
Berens River
Pigeon River
To Gods Lake
To Little Grand Rapids
Sturgeon Bay
Avamo Bay
Lake St. Martin
Jackhead
Matheson Island
Bloodvein
Bloodvein River
Pine Dock
Fisher Bay
Koostatak
Gull Harbour
Hecla
Hecla Island
Black Island
Hole River
Manigotagan
16
68
7
8
Riverton
Hnausa
Arnes
Camp Morton
Gimli
Victoria Beach
Hillside Beach
11
Pt. Alexander
Grand Beach
Grand Marais
Winnipeg Beach
59
9
Scanterbury



MAP III

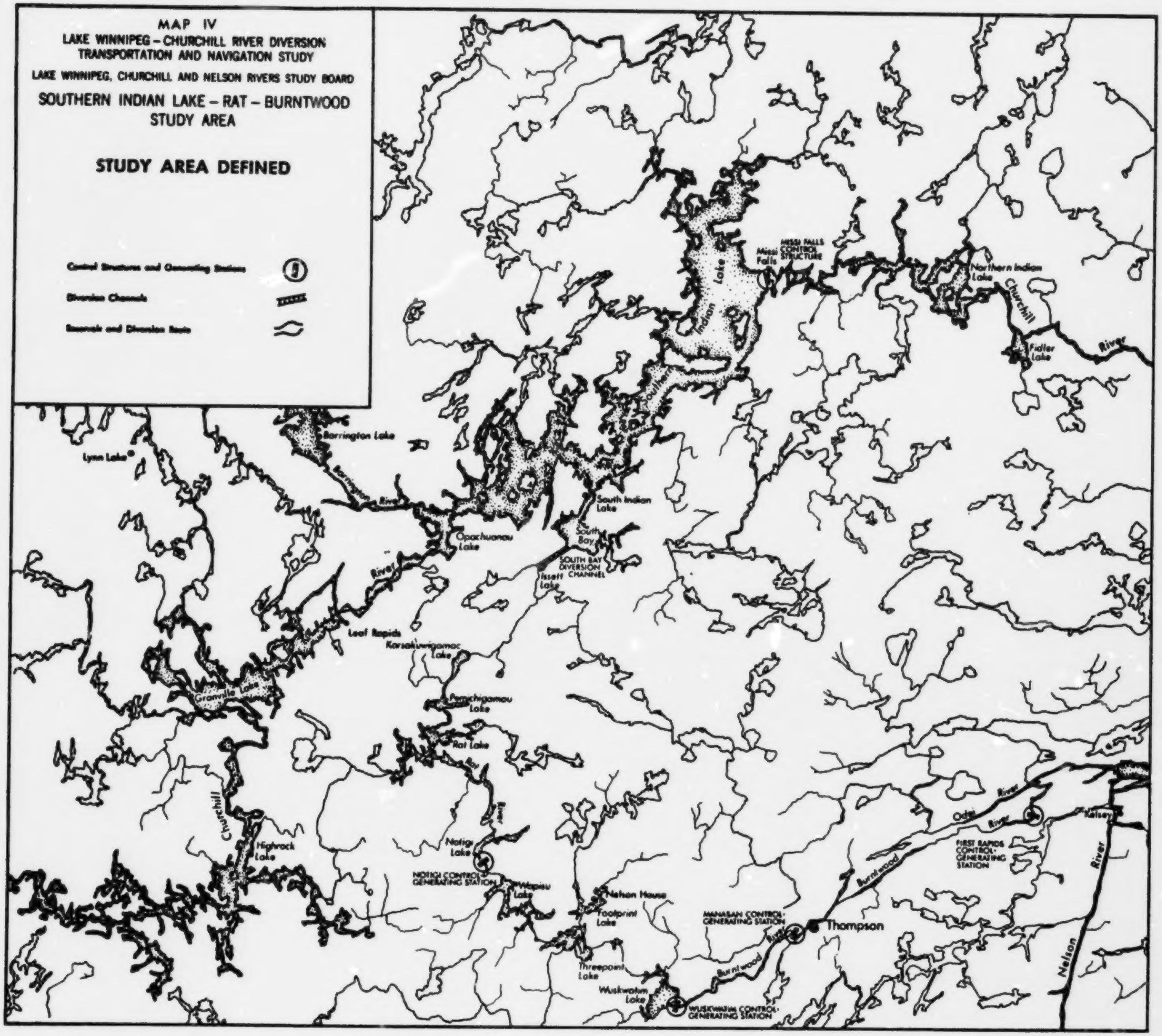
LAKE WINNIPEG – CHURCHILL RIVER DIVERSION
TRANSPORTATION AND NAVIGATION STUDY

LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

LAKE WINNIPEG STUDY AREA

AIR TRANSPORTATION

Manitoba Government Land Aerodrome ▲
Private Land Aerodrome ▣
Sea Plane Base
SCHEDULED AIR SERVICE
*Winnipeg – Berens River – Poplar River – Northward
5 0 5 10 15 20 25
Scale in Miles
Limestone Bay
2-Mile Channel
River
Grand Rapids
Long Point
Poplar River (Negginan)
Poplar
River
Reindeer Island
Berens Island
Berens River
Berens
River
Pigeon
River
Sturgeon Bay
Anama Bay
Jackhead
Lake St. Martin
Princess Harbour
Matheson Island
Bloodvein
Pine Dock
River
Loon Straits
Fisher Bay
Washow Bay
Gull Harbour
Black Island
Hole River
Hecla
Manigotagan
Riverton
Hecla Island
Hnausa
Arnes
Camp Morton
Gimli
Victoria Beach
Hillside Beach
Pt. Alexander
Grand Beach
Grand Marais
Winnipeg Beach
Scanterbury



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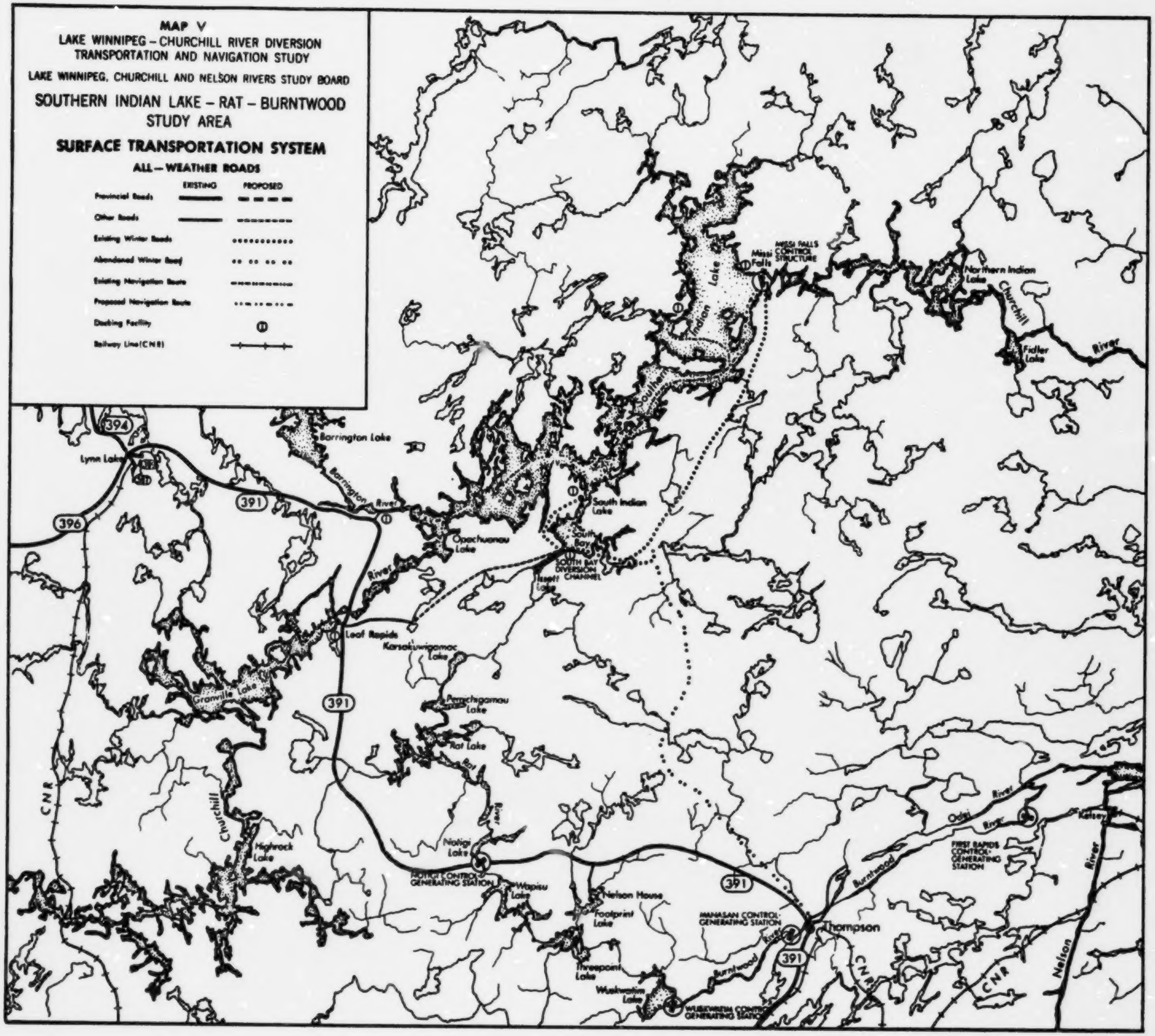
LAKE WINNIPEG – CHURCHILL RIVER DIVERSION
TRANSPORTATION AND NAVIGATION STUDY
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD
SOUTHERN INDIAN LAKE – RAT – BURNTWOOD
STUDY AREA

STUDY AREA DEFINED

Control Structures and Generating Stations
Diversion Channels
Reservoir and Diversion Route
Southern Indian Lake
Missi Falls
MISSI FALLS CONTROL STRUCTURE
Northern Indian Lake
Churchill River
Fidler Lake
Barrington Lake
Lynn Lake
Barrington River
Opachuanau Lake
South Indian Lake
South Bay
SOUTH BAY DIVERSION CHANNEL
Issett Lake
River
Leaf Rapids
Karsakuwigamac Lake
Granville Lake
Pemichigamau Lake
Rat Lake
Rat River
Churchill
Highrock Lake
Notigi Lake
NOTIGI CONTROL-GENERATING STATION
Wapisu Lake
Nelson House
Footprint Lake
Threepoint Lake
Wuskwatim Lake
WUSKWATIM CONTROL-GENERATING STATION
Burntwood
MANASAN CONTROL-GENERATING STATION
Thompson
Burntwood River
Odei River
FIRST RAPIDS CONTROL-GENERATING STATION
Kelsey
Nelson River



MAP V

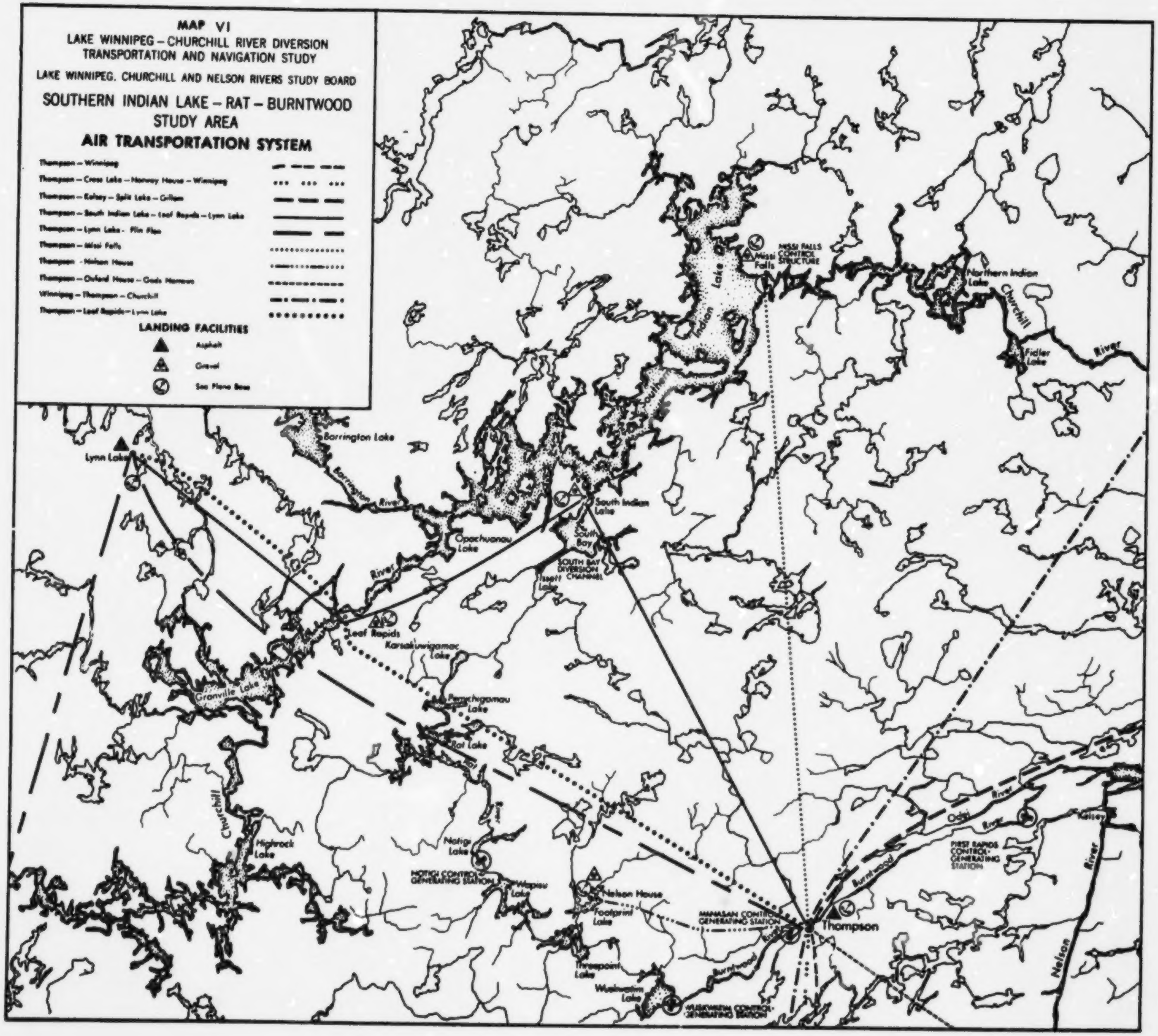
LAKE WINNIPEG – CHURCHILL RIVER DIVERSION
TRANSPORTATION AND NAVIGATION STUDY

LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SOUTHERN INDIAN LAKE – RAT – BURNTWOOD
STUDY AREA

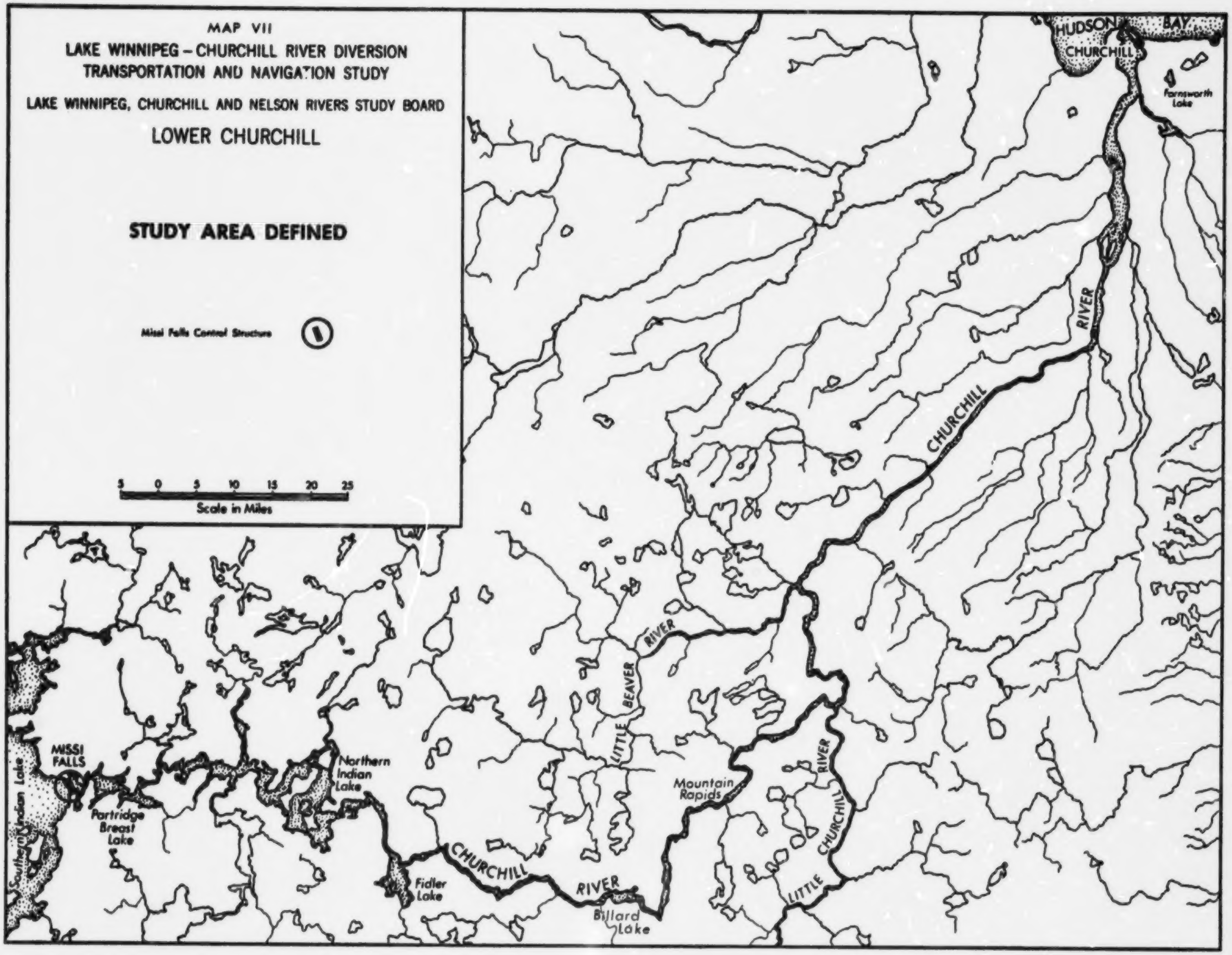
SURFACE TRANSPORTATION SYSTEM

ALL – WEATHER ROADS
EXISTING
PROPOSED
Provincial Roads
Other Roads
Existing Winter Roads
Abandoned Winter Road
Existing Navigation Route
Proposed Navigation Route
Docking Facility
Railway Line (CNR)
Southern Indian Lake
Missi Falls
MISSI FALLS CONTROL STRUCTURE
Northern Indian Lake
Churchill River
Fidler Lake
Barrington Lake
Barrington River
Lynn Lake
394
396
391
Opachuanau Lake
South Indian Lake
South Bay
SOUTH BAY DIVERSION CHANNEL
Issett Lake
Leaf Rapids
Karsakuwigamac Lake
Granville Lake
Pemichigamau Lake
Rat Lake
Rat River
Churchill
Highrock Lake
CNR
Notigi Lake
NOTIGI CONTROL GENERATING STATION
Wapisu Lake
Nelson House
Footprint Lake
Threepoint Lake
Wuskwatim Lake
WUSKWATIM CONTROL GENERATING STATION
Burntwood River
MANASAN CONTROL GENERATING STATION
Thompson
Odei River
FIRST RAPIDS CONTROL GENERATING STATION
Kelsey
Nelson River



Thompson – Winnipeg
Thompson – Cross Lake – Norway House – Winnipeg
Thompson – Kelsey – Split Lake – Gillam
Thompson – South Indian Lake – Leaf Rapids – Lynn Lake
Thompson – Lynn Lake – Flin Flon
Thompson – Missi Falls
Thompson – Nelson House
Thompson – Oxford House – Gods Narrows
Winnipeg – Thompson – Churchill
Thompson – Leaf Rapids – Lynn Lake
LANDING FACILITIES
Asphalt
Gravel
Sea Plane Base
Lynn Lake
Barrington Lake
Barrington River
Opachuanau Lake
River
South Indian Lake
South Bay
SOUTH BAY DIVERSION CHANNEL
Issett Lake
Leaf Rapids
Karsakuwigamac Lake
Granville Lake
Pemichigamau Lake
Rat Lake
Churchill
Highrock Lake
Notigi Lake
NOTIGI CONTROL GENERATING STATION
Wapisu Lake
Nelson House
Footprint Lake
Threepoint Lake
Wuskwatim Lake
WUSKWATIM CONTROL-GENERATING STATION
MANASAN CONTROL GENERATING STATION
Thompson
Burntwood
River
Odei River
Kelsey
FIRST RAPIDS CONTROL-GENERATING STATION
Nelson River
Missi Falls
MISSI FALLS CONTROL STRUCTURE
Southern Indian Lake
Northern Indian Lake
Churchill River
Fidler Lake

MAP VI
LAKE WINNIPEG – CHURCHILL RIVER DIVERSION
TRANSPORTATION AND NAVIGATION STUDY
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD
SOUTHERN INDIAN LAKE – RAT – BURNTWOOD
STUDY AREA
AIR TRANSPORTATION SYSTEM



MAP VII

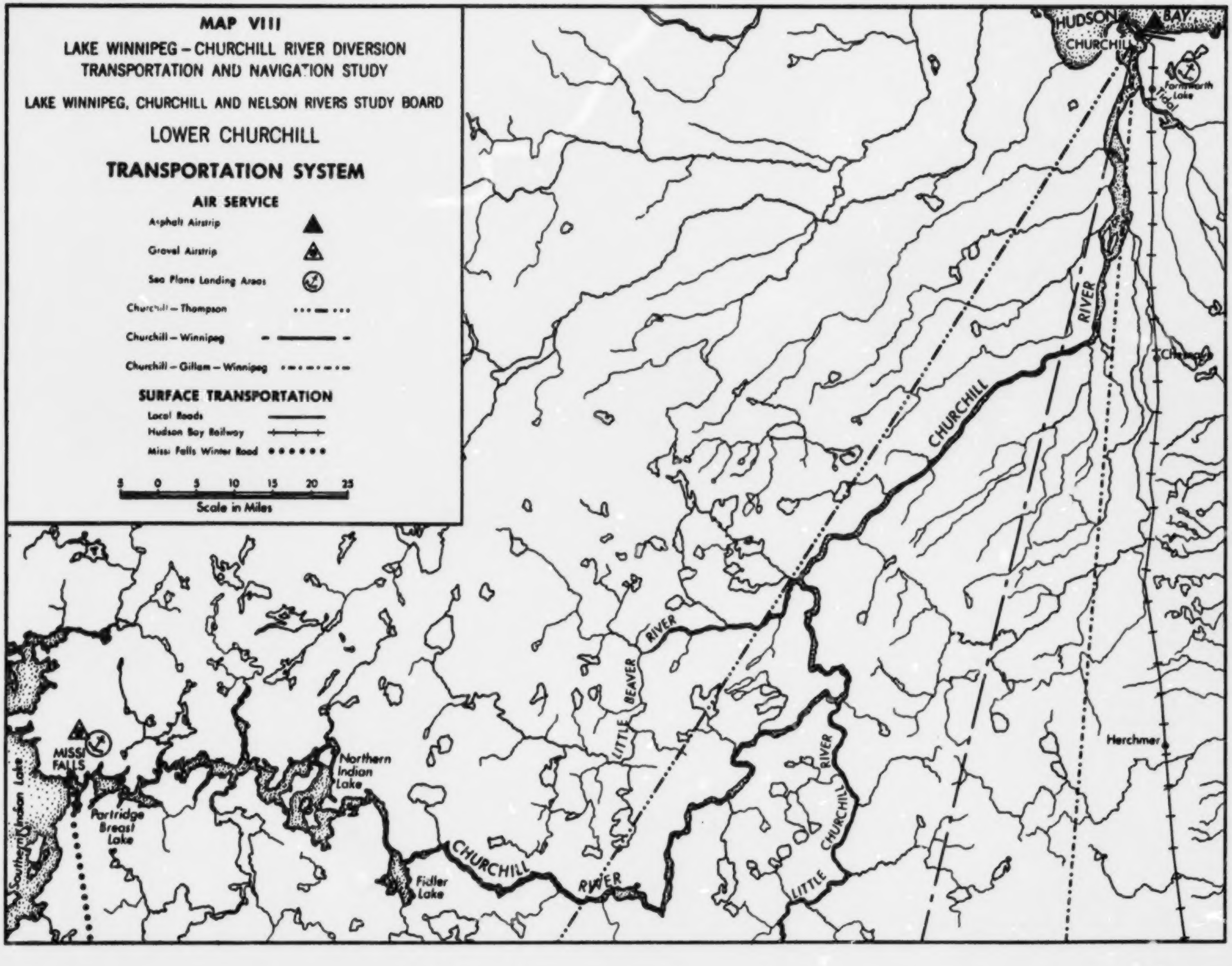
LAKE WINNIPEG – CHURCHILL RIVER DIVERSION
TRANSPORTATION AND NAVIGATION STUDY

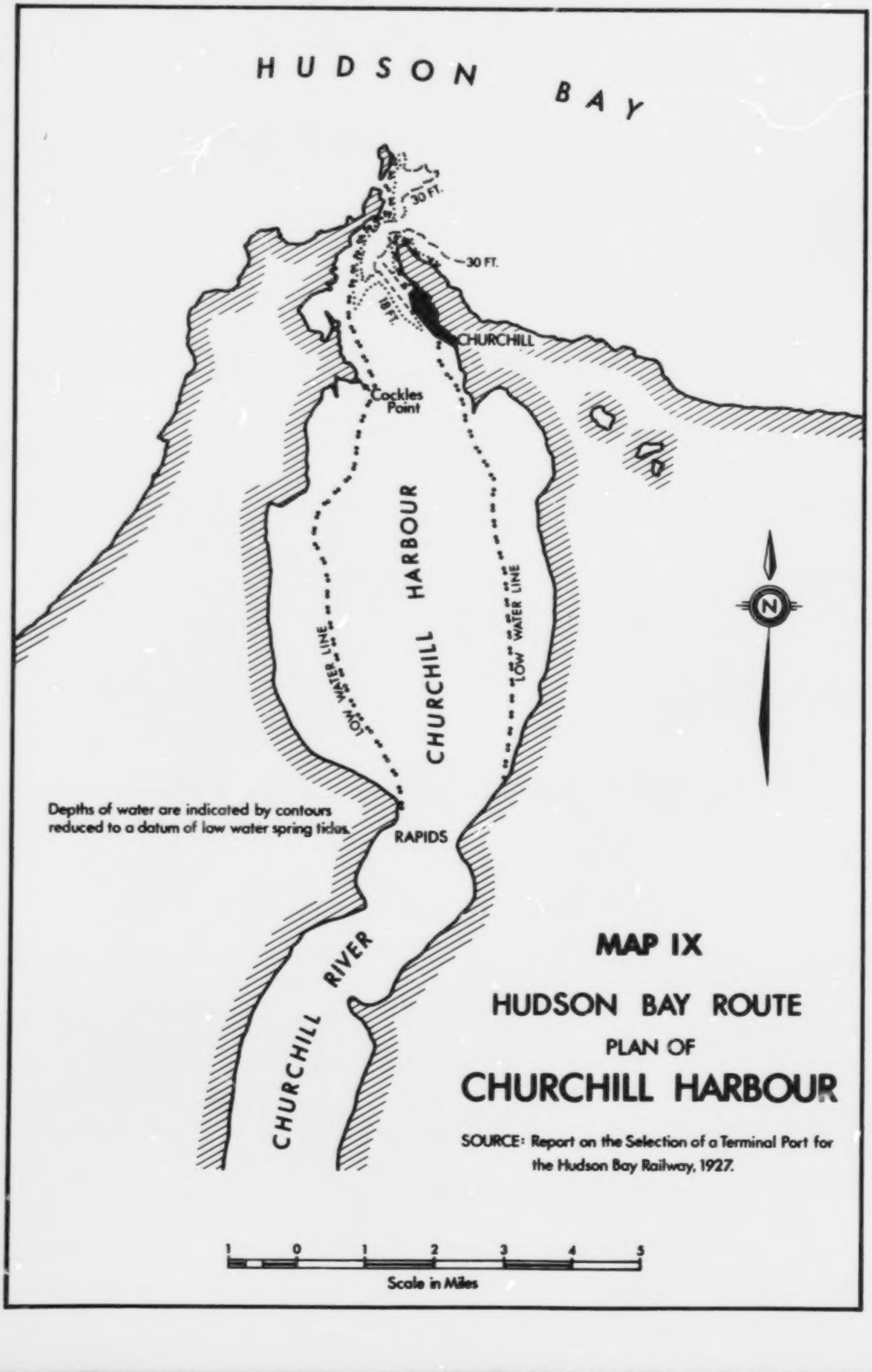
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

LOWER CHURCHILL

STUDY AREA DEFINED

Missi Falls Control Structure
1
5 0 5 10 15 20 25
Scale in Miles
HUDSON BAY
CHURCHILL
Farnsworth Lake
CHURCHILL RIVER
LITTLE BEAVER RIVER
LITTLE CHURCHILL RIVER
Mountain Rapids
Billard Lake
Fidler Lake
Northern Indian Lake
MISSI FALLS
Partridge Breast Lake
Southern Indian Lake




HUDSON BAY
30 FT.
30 FT.
18 FT.
CHURCHILL
Cockles Point
CHURCHILL HARBOUR
LOW WATER LINE
LOW WATER LINE
RAPIDS
CHURCHILL RIVER
N
1
0
1
2
3
4
5
Scale in Miles

Depths of water are indicated by contours reduced to a datum of low water spring tides.

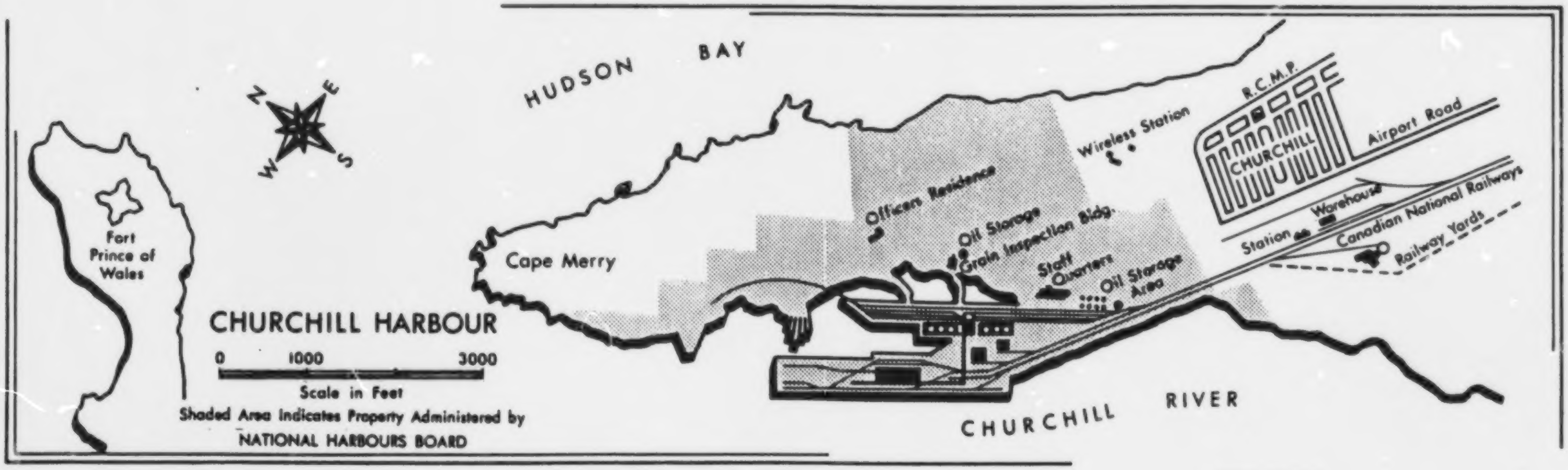
MAP IX

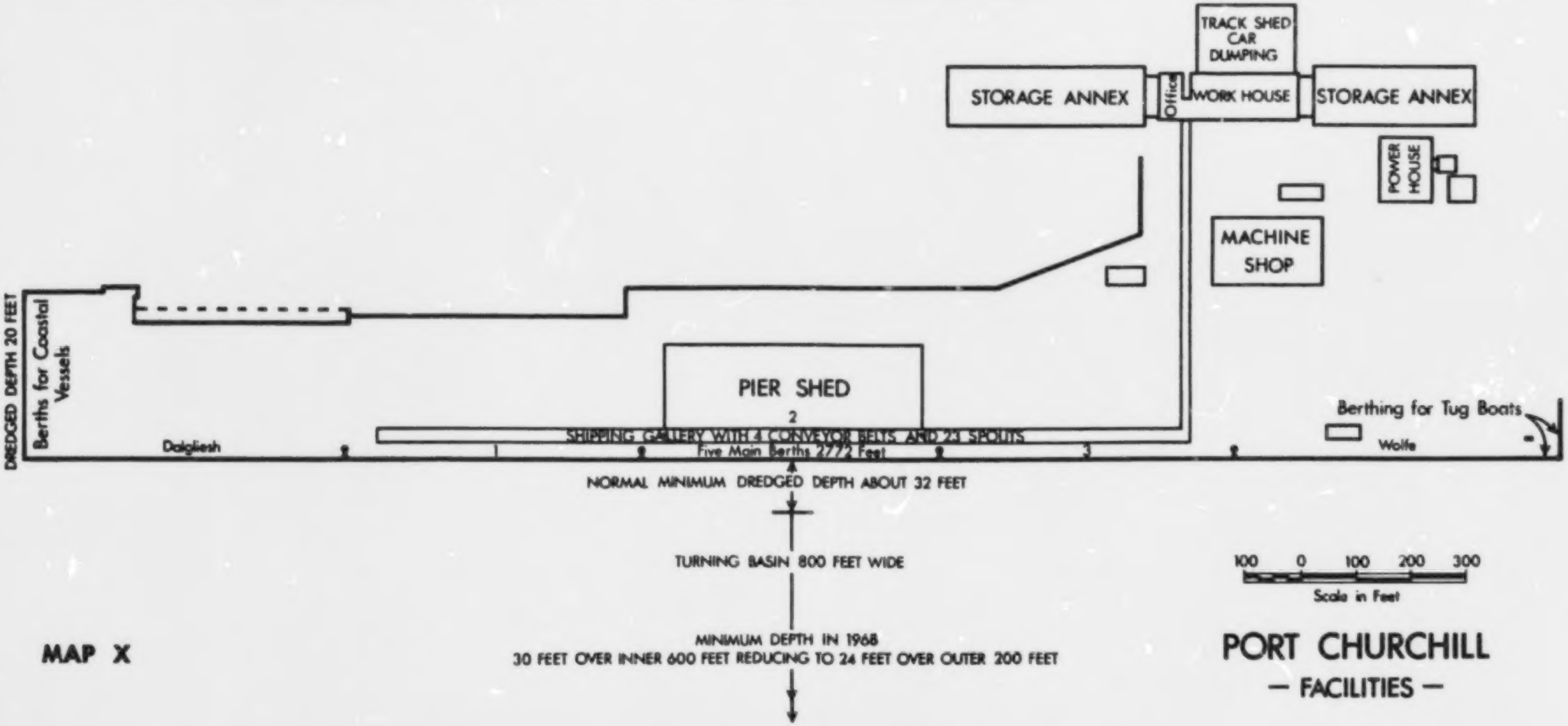
HUDSON BAY ROUTE

PLAN OF

CHURCHILL HARBOUR

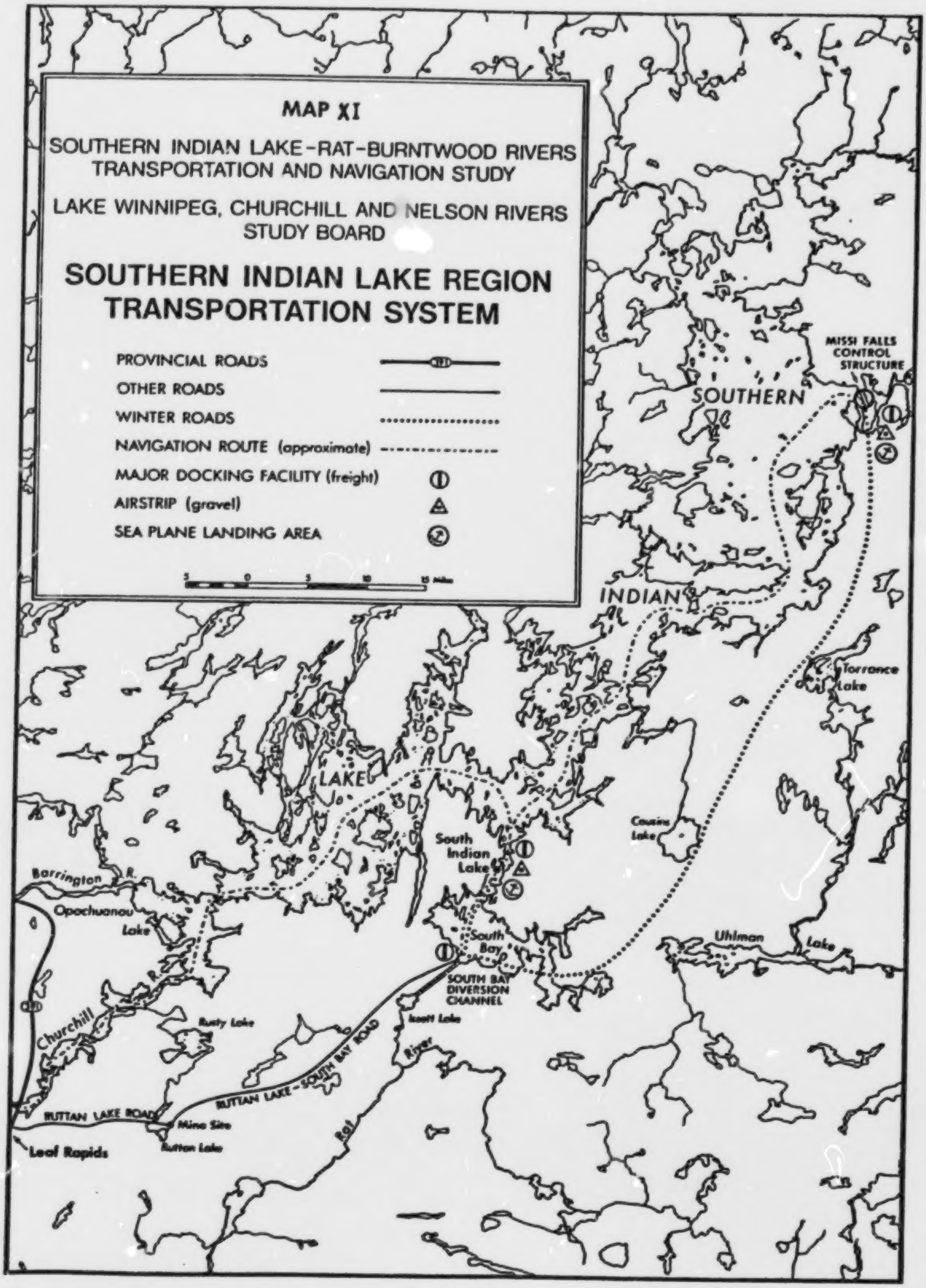
SOURCE: Report on the Selection of a Terminal Port for the Hudson Bay Railway, 1927.


CHURCHILL HARBOUR
0
1000
3000
Scale in Feet
Shaded Area Indicates Property Administered by
NATIONAL HARBOURS BOARD
N
E
S
W
HUDSON BAY
Fort Prince of Wales
Cape Merry
Officers Residence
Oil Storage
Grain Inspection Bldg.
Staff Quarters
Oil Storage Area
Wireless Station
R.C.M.P.
CHURCHILL
Airport Road
Station
Warehouse
Canadian National Railways
Railway Yards
CHURCHILL RIVER


TRACK SHED CAR DUMPING
STORAGE ANNEX
Office
WORK HOUSE
STORAGE ANNEX
POWER HOUSE
MACHINE SHOP
DREDGED DEPTH 20 FEET
Berths for Coastal Vessels
PIER SHED
2
Berthing for Tug Boats
SHIPPING GALLERY WITH 4 CONVEYOR BELTS AND 23 SPOUTS
Dalgliesh
1
Five Main Berths 2772 Feet
3
Wolfe
NORMAL MINIMUM DREDGED DEPTH ABOUT 32 FEET
TURNING BASIN 800 FEET WIDE
MINIMUM DEPTH IN 1968
30 FEET OVER INNER 600 FEET REDUCING TO 24 FEET OVER OUTER 200 FEET
100
0
100
200
300
Scale in Feet

MAP X

PORT CHURCHILL
— FACILITIES —



MAP XI

SOUTHERN INDIAN LAKE-RAT-BURNTWOOD RIVERS TRANSPORTATION AND NAVIGATION STUDY

LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SOUTHERN INDIAN LAKE REGION TRANSPORTATION SYSTEM

PROVINCIAL ROADS
OTHER ROADS
WINTER ROADS
NAVIGATION ROUTE (approximate)
MAJOR DOCKING FACILITY (freight)
AIRSTRIP (gravel)
SEA PLANE LANDING AREA
5 0 5 10 15 Miles
MISSI FALLS CONTROL STRUCTURE
SOUTHERN
INDIAN
LAKE
Torrance Lake
Cousins Lake
South Indian Lake
Barrington R.
Opachuanau Lake
South Bay
SOUTH BAY DIVERSION CHANNEL
Uhlman Lake
Churchill R.
Rusty Lake
Issett Lake
Rat River
RUTTAN LAKE-SOUTH BAY ROAD
RUTTAN LAKE ROAD
Mine Site
Ruttan Lake
Leaf Rapids

APPENDIX 4 - M

OUTLET LAKES TRANSPORTATION AND NAVIGATION STUDY

OUTLET LAKES
TRANSPORTATION AND NAVIGATION STUDY

by

K. A. ROSIN, F. F. SACCOMANNO and S. TRACHTENBERG
Faculty of Administrative Studies
University of Manitoba
Winnipeg, Manitoba
January, 1973

for

THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SPECIAL NOTE

THE CONCLUSIONS AND RECOMMENDATIONS CONTAINED IN THIS APPENDIX ARE THOSE OF THE AUTHOR(S) AND ARE NOT NECESSARILY THE SAME AS THE CONCLUSIONS AND RECOMMENDATIONS OF THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD AS EXPRESSED IN THE SUMMARY REPORT AND THE TECHNICAL REPORT.

ERRATA

March 2, 1973

PAGE OR MAP NUMBER	
Page 51	the species of fish for North Playgreen Lake (VA(1)(b)) should read sturgeon not trout.
Map VIII Appendix Land Transportation	the winter road shown from Jenpeg to Cross Lake should be deleted since the actual route of the winter road begins at the Minago River crossing of the Jenpeg access road and follows the Lake directly to Cross Lake community.
Map IX Appendix Water Transportation	no navigable channel exists through the Metchanais Rapids. Omit extension of navigable channel line where it enters the Metchanais Rapids.

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1. Groups and individuals contracted to the Study Board

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Limnology-Eutrophication Section, Freshwater Institute, Canada Department of the Environment

Acres Consulting Services Limited

F.F. Slaney and Company Limited

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Resources Management Branch, Canada Department of the Environment

2. Provincial Government Agencies

Manitoba Department of Northern Affairs

Manitoba Department of Municipal Affairs

Manitoba Department of Highways

Manitoba Department of Industry and Commerce

3. Federal Government Agencies

Canada Department of Public Works

Canada Department of Transport

4. Transport Carriers

Marine Transport Limited

Northland Freight and Forwarding Company

M. and S. Freighting

Canadian National Railways

PREFACE

Historically, the northern sector of the Province of Manitoba has remained outside the mainstream of modern transportation development. However, in the past few years, due primarily to increasing resource activity, particularily mining and forestry, this area of the province has become incrementally more important. As a direct result of this emerging importance, together with the realization by the local population and by residents of southern Manitoba, of the benefits which may result from closer physical ties with the rest of the province, some very significant improvements in the transportation system have taken place. A prime example is the extension of the provincial highway network as far north as Thompson and shortly, Lynn Lake.

The planned Hydro electric development of the Churchill-Nelson Rivers, including the regulation of Lake Winnipeg, may have far-reaching effects - physical, social and economic - on the future structure and development of this region. More specifically, Hydro development may have the effect of modifying both the existing and future physical transportation system in the region and the "modal mix" for the movement of people and goods to, from and within the various areas of the region.

In a study of this nature, due consideration should be given to future transportation technology. However, because of the still largely experimental nature of this technology, a great deal of prognostication is required, which lies outside the scope of this particular study. As a result, our efforts will be concentrated on the effects of the Hydro development on the existing modes of transportation in the areas of concern. It can be expected, however, that any adoption or adaptation of new transportation technology in northern Manitoba such as all-terrain and air cushion vehicles would also influence the nature of the transportation system in the areas where Hydro development is proceeding.

ABSTRACT

Due to priorities established by the Study Board, this report concentrates on the implications to transportation and navigation of Hydro development in the Outlet Lakes area.

An inventory of the existing transportation infrastructure as well as a discussion of the physical effects of Hydro development on this infrastructure form the first phase of the study.

Subsequently the report examines the resource base in the study area, as well as the existing methods of removing particular resource products. This section also considers modifications to the existing resource product removal methods as facilitated or initiated by Hydro development, by means of a cost analysis procedure.

The report also examines the existing person travel patterns and the possible modifications to these patterns as a result of Hydro development.

The importation of commodities into the communities in the Outlet Lakes area is discussed in terms of existing methods and modifications to these methods as a result of Hydro development. This analysis follows a similar procedure to that adopted for resource removal methods.

Subject to this overall analysis, the general impact of Hydro development on all phases of transportation and navigation (existing and potential) in the Outlet Lakes area is assessed and several conclusions are drawn.

PART ONE

SUMMARY

SUMMARY

I Recommendations

As a result of this study a number of recommendations are presented with regard to the effect of Hydro development on transportation and navigation in the Outlet Lakes area.

(a) A detailed benefit-cost analysis should be undertaken to determine the economic feasibility of a navigational lock in the Jenpeg control structure in terms of potential marine traffic.

(b) Detailed information concerning all aspects of an East Channel control structure should be made available.

(c) Encroachment of roads into the designated passive recreation area along the East Channel must be kept to a minimum.

(d) The portions of local road in Cross Lake community which will be affected by flooding due to Hydro development should be upgraded and/or realigned to an elevation above the maximum post-regulation water level (elevation 685.9 feet) in order to maintain intra-community accessibility.

(e) Any extension or upgrading of the local road networks at Cross Lake and Norway House should be preceded by a detailed investigation of the effects of Hydro development on these network modifications.

(f) A detailed investigation of the effect of altered current flow and water level fluctuations (due to Hydro regulation) on freeze-thaw cycles and ice formation should be undertaken. This data is of direct bearing on sea plane bases and winter roads.

(g) The wharves which are affected by flooding (at Whiskey Jack Portage and Rossville) should be upgraded to a level above the maximum regulated flood stage (elevation 715.0 feet and 685.9 feet respectively) or relocated in alternative sites.

(h) Any islands which will be fully or partially inundated as a result of Hydro development should be marked as an aid to both marine vessels and sea planes.

II Objectives

(a) To investigate the implications of Hydro development for the existing and proposed transportation and navigation facilities and services in the study area.

(b) To analyze the costs related to transportation and navigation for the movement of goods and people as affected by Hydro development.

III Terms of reference

(a) An examination and analysis of probable effects on transportation and navigation as a consequence of Hydro development.

(b) As a result of the priorities established by the Study Board, this report will focus on the effects of Hydro development on transportation and navigation in the Outlet Lakes area.

(c) A subsequent report, consisting of an overview of transportation-navigation implications to the remaining areas based on the available information which may be influenced by Hydro development, will be submitted at a later date.

IV Study area

The area to be considered in this report is located immediately to the north of Lake Winnipeg and is commonly referred to as the Outlet Lakes area. The communities in this area include Cross Lake, Norway House and Warren Landing. The Outlet Lakes includes the following significant drainage: Lakes Playgreen, Little Playgreen, Kiskittogisu, Kiskitto, Pipestone, Cross, Walker as well as the East and West Channels of the Nelson River and the Minago River.

V Method of approach

The initial phase of the approach taken in this report examines the major features of Hydro development (Jenpeg control structure, diversion channels and associated works) and the immediate physical implications to their surroundings. This is undertaken in order to provide the basis for the subsequent assessment of the ramifications of this development to transportation and navigation in the Outlet Lakes area.

The transportation infrastructure in the Outlet Lakes area (all existing land, air and water routes and facilities) is inventoried. Subsequent to this, an assessment is undertaken of the physical effects (flooding, freeze-thaw cycles, water level fluctuations, erosion, etc.) of Hydro development on this infrastructure.

As a result of consultation with various federal and provincial government departments and agencies, the existing and potential resource base in the Outlet Lakes area was identified, both in terms of area delineation and significance of resource. The resources considered include: furs, fish, forestry, minerals and recreation. Fishing and forestry provide the bulk of the export traffic from this area and as a result the removal methods presently used for these resource products are examined in greater detail. Both existing and alternative methods of removal of these resource products as facilitated or initiated by

Hydro development are examined by obtaining a range of potential outbound traffic volumes and the associated costs of transportation for each resource. The results of this analysis are presented in a series of tables, graphs and accompanying text.

A discussion of movement of people to, from and within the Outlet Lakes area and the Hydro development implications to this movement is included in a subsequent section.

With regard to the commodities imported by the communities of Cross Lake and Norway House (i.e. fuel oil, perishables and general merchanidse) a similar analysis to that of fish and forest product removal is undertaken, considering existing and potential import volumes by various methods and the implications of Hydro development on these methods. The results of this analysis are presented in a series of tables, graphs and accompanying text.

The cost analysis procedure which forms the major part of the method of approach adopted for this study does not consider capital expenditures for the extension of and/or modifications to the existing transportation infrastructure. Although capital cost estimates were available for certain extensions and modifications (eg. the possible dock at Jenpeg), they were not available for all alternatives considered (eg. the possible road extension from Jenpeg to

Norway House). Therefore inclusion of capital expenditures in the analysis would have meant possible gross inaccuracies in some of the results, due to speculation regarding certain cost factors.

As a result of the overall analysis, discussed above, general implications and possible alternatives to transportation and navigation in the Outlet Lakes area as initiated and facilitated by Hydro development are assessed. Subsequently several conclusions are drawn based on this assessment.

PART TWO

COMPREHENSIVE REPORT

I OBJECTIVES AND TERMS OF REFERENCE

As a component of the overall study undertaken by the Lake Winnipeg, Churchill and Nelson Rivers Study Board, this report contains the results of an investigation into the implications of the hydro-electric power development program proposed by Manitoba Hydro for existing and proposed transportation and navigation facilities and services in the study area.

It is also an objective of this study to include an analysis of costs related to transportation and/or navigation (water movement) of goods and of people where such an analysis is feasible.

The initial phase of the study will seek to determine the physical impact of the hydro-electric development on the existing transportation infra-structure. Subsequent to this, a determination is made of the effects of Manitoba Hydro's development on the service aspect of transportation.

The terms of reference envisage a comprehensive examination and analysis of the probable effects on transportation and navigation as a consequence of the regulation of Lake Winnipeg and diversion of the Churchill River as illustrated on Map II.

As a result of the priorities established by the Study

Board, a more detailed investigation of one specific area of the overall Hydro development known as the Outlet Lakes, was deemed essential due to the programming of construction activity (now underway) in this area. A report to be submitted by March 31, 1973 will include an overview of the other areas (the South Indian Lake, Lake Winnipeg and the Rat, Burntwood, Lower Nelson and Lower Churchill Rivers areas) which may be used as a basis for more intensive investigation and a further report at a later date. In assessing transportation as applied to the above specific areas a certain degree of cohesion may be lost since a transportation system as such cannot be sectionalized arbitrarily. However, keeping in mind the aforementioned Study Board priorities, the degree of cohesion lost was not considered significant in view of the still generally rudimentary conditions of most of the transportation facilities in Northern Manitoba.

II STUDY AREA

A. Location

The area which is of initial concern in this report encompasses the general geographic region immediately to the north of Lake Winnipeg as shown on Map I. This region is commonly known as the Outlet Lakes area and henceforth in this study will be referred to as such.

The significant drainage in this designated area includesLakes Playgreen, Little Playgreen, Kiskittogisu, Kiskitto, Pipestone, Cross and Walker, as well as the East and West Channels of the Nelson River and the Minago River.

The communities of direct interest in this area include Cross Lake, Norway House and Warren Landing. The population of Cross Lake (including Indian Reserve 19) has increased from a population of 1,840[1] in 1968 to a population of 2,000[2] today. Norway House contains the largest concentration of people in the Outlet Lakes area. Its population has increased from 2,275[3] in 1966 to 2,524 today. These figures include the Indian Reserve (I.R. Number 17) and the area known as Rossville. Although Warren Landing has been included as a community in this study, its population (approximately 27) is very small in relation to Cross Lake or Norway House.

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[1] The population of Cross Lake in 1968 and the present population of Norway House and Warren Landing were taken from figures obtained by the Manitoba Department of Northern Affairs.

[2] M.M. Dillon, Cross Lake Transportation Study, 1971.

[3] Census of Canada, 1966.

The study area is located outside the main provincial land transportation network (Map IV). The three major highways, PTH10, PTH6, PR391 and C.N. Railway which now provide the only land transportation link with the southern region of the province do not directly serve the Outlet Lakes area. Indirect service, however, is provided by integration of the above network with other modes (eg. winter truck road barge, etc.). The study area is now provided access to the southern region by the water system consisting of Lake Winnipeg, Playgreen Lake and Cross Lake. The major freight receiving centres on Lake Winnipeg are Berens River, Poplar River, Grand Rapids, Gimli, Selkirk and Winnipeg (Map V). Several commercial air routes service the study area, most of which originate in Winnipeg (Map VI). In addition to these routes, charter service is available from virtually any major airstrip or sea plane base in the North. The major northern air facilities including those in the Outlet Lakes area are also shown on Air Transportation maps (Map VI).

B. Significance of the area

In terms of the power output of the upper Nelson River Hydro development, most of the interconnecting water system which comprises the Outlet Lakes should be considered as a part of the Lake Winnipeg reservoir due to the fact that a control structure at the inlet of Cross Lake will regulate all upstream water bodies including Lake Winnipeg, within the range of elevation 711 to 715 feet[1] (with the exception of Kiskitto Lake as described later in this report).

The importance, therefore, of the Lake Winnipeg-Outlet Lakes reservoir stems from the fact that the outflow of this reservoir will be used to augment low flows on the upper Nelson River, essentially during the winter months. In so doing emergency situations with regard to power production caused by low water levels can be dealt with adequately, rather than depending on the unpredicability of natural conditions[2].

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[1] Program for regulation of Lake Winnipeg, Province of Manitoba, 1972.

[2] Ibid.

III MAJOR FEATURES OF HYDRO DEVELOPMENT AND IMMEDIATE PHYSICAL IMPLICATIONS[1]

A. Jenpeg

Construction of a control structure and generating station at the outflow of the West Channel of the Nelson River into Cross Lake has been underway since early 1972. This site, known as Jenpeg, has certain immediate physical effects on the area.

It provides the initial bridgehead across the West Channel of the Nelson River, linking Ross Island to the rest of Manitoba and the actual design of the control structure incorporates a roadway which is of sufficient width for two-way vehicular traffic. Due to the increase in the level of the upstream waterbodies, to the ranges of elevation 711 to 715 feet, as a result of the Jenpeg control structure, the depth of the West Channel of the Nelson may be increased from 2 to 5 feet (estimate). Since the Jenpeg generating station will require that a certain head be maintained for power generation, the levels on the downstream or tailwater side of Jenpeg (i.e. Cross Lake) will fluctuate much more frequently than in the natural state. Although the tailwater levels will fluctuate between

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[1] Map VII indicates the location of major hydro projects in the Outlet Lake area.

674.9 and 685.9 feet, which is basically within the historical range, the rate of fluctuation will be much more frequent.

B. Diversion channels[1]

In order to improve the flow through the outlet of Lake Winnipeg and Playgreen Lake, the development includes provision for the excavation of three diversion channels, namely:

(1) 8-Mile Channel

- this is a connection between Kiskittogisu Lake and Playgreen Lake via the Kiskittogisu River and a man-made channel.
- the median flow is established at 2.0 fps and the 100 year flood flow is expected to be 4.3 fps.
- the channel is designed for a minimum depth of 25 feet year round with no freeze-thaw cycles expected.
- the channel width varies from a maximum of 1,000 feet at the Playgreen Lake end to 425 feet at the Kiskittogisu Lake end.
- the channel is cut through primarily clay and peat material and has side slopes designed to minimize

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[1] The design properties of these channels are taken from Dredge Soil Studies and Aspects of Channel Operations, Water Resources Branch, July 1972.

erosion and bank instability.

- the area is characterized by a high percentage of swamp and bog (greater than 50 percent) containing from 0 to 15 percent permafrost.[1]

(2) 2-Mile Channel

- provides a connection between Lake Winnipeg and Playgreen Lake via an excavated channel.
- median flow is estimated at 2.0 fps and the 100 year flood flow is expected to be 4.3 fps.
- minimum design depth of channel is 25 feet year round with no expected freeze-thaw cycles.
- the channel width is approximately 410 feet throughout.
- the channel is cut through primarily clay and peat material having side slopes which minimize erosion and bank instability.
- the area is characterized by a high percentage of swamp and bog (greater than 50 percent) containing from 15 to 50 percent permafrost.[2]

(3) The Ominawin Bypass

- is a man-made channel created to divert flow from the Ominawin Rapids on the west channel of the Nelson River.

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[1] Department of Soil Science, Pedology Section, University of Manitoba.

[2] Ibid.

- the median flow is 2.0 fps and the 100 year flood flow is 4.3 fps.
- depth of channel is 25 feet with no freeze-thaw cycle.
- the channel width is approximately 1,500 feet throughout.
- the channel cuts through primarily rock, clay and peat material having side slopes which minimize erosion and bank instability.
- accessibility to the Ominawin construction site is provided by a Hydro access road connection to Jenpeg approximately 8 miles downstream of the West Channel.

C. Kiskitto Lake Dam and Diversion

Due to the low elevation of Kiskitto Lake (approximately 695 feet), Manitoba Hydro has decided to isolate the lake from the Jenpeg forebay to prevent large scale flooding in the Kiskitto Lake drainage basin. In order to accomplish this a dam will be constructed at the outlet of the lake. Provision will be made for adequate drainage by construction of a diversion channel from Kiskitto Lake to Black Duck Creek and thence via the Minago River to Cross Lake. A control structure on this drainage channel will allow Kiskitto Lake to be maintained within the bounds of its natural water levels.

D. The East Channel control structure

Initially Manitoba Hydro had intended to use the Jenpeg structure for water control; however, it was later considered advantageous to incorporate a generating station into the structure. As a result of this modification, water flow on the East Channel of the Nelson River, bypassing the Jenpeg site, would become wastage in terms of power production. A control structure on the East Channel would utilize this flow when required at the Jenpeg generating station. Although this additional structure is still under study, for the purpose of this report it has been included as a significant part of the overall Hydro development.

Spillage through the structure may be reduced at different times of the year, depending on head requirements at Jenpeg. Since no definite decision has been made regarding the location of the East Channel control structure, information on possible effects of such a structure has not been made available to us. One site often mentioned as suitable for the location of such a control structure is in the vicinity of Sea River Falls.[1]

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[1] Sea River Falls provides the only significant drop in gradient (5 feet) on the East Channel. Downstream of Sea River Falls at a point where the East Channel begins to branch out there is another minor section of rapids called Sugar Falls which may offer an alternative to the Sea River Falls (Map VII).

One can speculate, however, that a control structure on the East Channel may affect the internal currents on Cross Lake and Little Playgreen Lake. The significance of such an effect cannot be rated on the basis of the information available at this time.

The structure itself would provide an initial bridgehead across the Nelson River's East Channel. The significance of this is considered later in this report.

IV EFFECTS OF HYDRO DEVELOPMENT ON THE TRANSPORTATION INFRASTRUCTURE

This section of the report examines the effects of Hydro development on the transportation infrastructure in the Outlet Lakes area. This infrastructure is, for the purposes of this study, divided into six major categories: all-weather roads, winter roads, railways, navigation, sea plane landing bases and airstrips. The physical effects on the existing transportation network as well as modifications to this network as a result of Hydro development are considered for each category of the infrastructure.

A. All-weather roads

The all-weather roads of Northern Manitoba fall into four general classifications, all of which are represented in the Outlet Lakes area (Map VIII).

(1) Primary paved: Roads in this category meet several minimum standards such as vertical and horizontal alignment sufficient to provide safety at speeds of 60 to 70 miles per hour. The roadway consists of two lanes, 12 feet in width, with shoulders of 6 to 8 feet on both sides of the roadway. The road surface is paved with concrete or asphalt.

In the Outlet Lakes area only Provincial Trunk Highway

6, at the western periphery, falls within this classification. Provincial Trunk Highway 6 extends from Winnipeg to Ponton approximately 364 miles to the north, where it intersects with Provincial Road 391.

(2) Secondary paved or gravel: Roads in this category meet minimum vertical and horizontal alignment specifications to provide safety at speeds up to 60 miles per hour. The roadway consists of two lanes, each lane is approximately 12 feet wide with 6 foot shoulders. The road surface is either paved asphalt or gravel.

In the Outlet Lakes area, Provincial Roads 391 and 373 fall within this classification. Provincial Road 391 extends from Ponton (at the intersection of Provincial Trunk Highway 6) to Thompson 95 miles to the northeast (Map IV). At Thompson Provincial Road 391 deviates to the northwest in the direction of Nelson House and Lynn Lake. In the Outlet Lakes area Provincial Road 391 is presently gravel surface; however, construction is underway to pave the section from Ponton to Soab Lake by the fall of 1973. Provincial Road 373, which forms a part of the Jenpeg access road, extends for 19.4 miles from Provincial Road 391 to Sipiwesk Lake. This road is gravel surfaced and was built by the Department of Highways for Churchill Forest Industries under the terms of the agreement with the company. It is now used essentially to ship construction material to the Jenpeg site.

(3) Pioneer roads: The pioneer road, forms the initial stage in the construction of a road network in the north. Essentially pioneer status is little more than throughway clearing in winderness to establish some form of rudimentary connection between points. As a result the specifications for this category are minimal. The roadway consists of a 34 foot wide, unmarked strip. The surface material is either gravel or compacted earth. There is no vertical alignment provided on a pioneer road, although horizontal alignment is included in the specifications to facilitate future improvements.

The Outlet Lakes area does not have any pioneer roads outside community borders. There are proposals at present for extension of the Jenpeg access road to Cross Lake by initial construction on a pioneer status.[1]

(4) Other roads: These roads are characterized by the fact that they are private and are constructed to provide access to specific areas of activity. Roads built and maintained by Manitoba Hydro to serve Hydro construction sites and by C.F.I., to serve forestry operations in

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[1] M.M. Dillon, Cross Lake Transportation Study, 1971.

certain areas, are included in this category.

In the Outlet Lakes area the following roads are included in this category:

i) PR 373 - Jenpeg (Jenpeg access road)[1]

Length: 35.5 miles

Surface: Gravel

Purpose: Hydro road to provide access to construction at Jenpeg.

ii) Dunlop - Clarke Lake

Length: 4.5 miles

Surface: Gravel

Purpose: C.F.I. road

iii) Jenpeg - Ominawin Bypass

Length: 8 miles

Surface: Gravel

Purpose: Hydro road to provide access to construction at Ominawin channel.

iv) 8-Mile, 2-Mile and Ominawin Roads

Length: 8 miles, 2 miles and 2 miles respectively

Surface: Gravel

Purpose: These roads are basically for internal access on the respective hydro construction sites. They are not connected to the external road network of the province.

A complete up-to-date inventory of roads in this category is difficult to obtain since extensions and improvements are taking place continuously. The policy of the Manitoba Department of Highways in this respect appears to be that the construction of roads required by Churchill Forest Industries and Manitoba Hydro projects will be initiated as required, with financial arrangements determined by joint agreement between the Department of Highways and either of these entities.

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[1] Constructed by Manitoba Department of Highways

(5) Effects of Hydro development on all-weather roads: In terms of any damage incurred to the above physical facilities either through flooding, bank instability or soil erosion as a result of Hydro development, it can be safely assumed that no such damage will take place. The only roads close enough to the water's edge to warrant attention are those roads operated by Manitoba Hydro to provide access to the construction sites. Since these roads were built with the development in mind it is unlikely they would be adversely affected by the development. The other roads (eg. PTH 6, PR 391, Dunlop-Clarke Lake) are well above the highest regulated flood stage of elevation 715 feet for the Outlet Lakes.

As indicated, Hydro development involves the construction of two control dams: one at Jenpeg and the other (still under study) on the East Channel of the Nelson River.

Together these two structures will provide the first land connection across the Nelson River. It is safe to assume that construction activity on the East Channel may necessitate a road to provide for the shipment of men and materials to the site.

A relevant question is: How has Hydro development accelerated the extent of road construction in the Outlet Lakes area? Without Hydro development there would be no control structure at Jenpeg and hence no need for an access road. The existing traffic (commodities and people), to and from the communities of Cross Lake and Norway House would not be sufficient to warrant any road connection at present. The prospect of such a connection, under present and potential traffic availability, would appear to be far into the future - probably at least a decade away. The access road to Jenpeg has spurred talk of extension to Cross Lake, 10 miles to the northeast. Certainly this could be a beneficial effect of Hydro development since it would decrease the surface isolation component of this community of 2,000 inhabitants. Other factors, one of which may be access to construction at the East Channel control site, may accelerate another extension of the Jenpeg road to the important community of Norway House. This form of activity, generated by the Hydro development, would seem to indicate a prospective connection from the major communities in the Outlet Lakes area (i.e. Norway House and Cross Lake) to the transportation corridor located to the northwest of this area. The ramifications of such a development on a regional scale cannot be easily understood at this time.

It is difficult to hypothesize as to the beneficial effect of Hydro development in terms of possible improved accessibility to communities in the area. Extension of Hydro access roads will depend on some compromise between commercial traffic availability on an extended road network, social demands and government policy of the day. This report attempts to provide some insight into the first two variables, during the discussion of the available and potential resource activities and likely transportation costs. Only after a general assessment of this nature can a consensus be obtained regarding the extension of the road network from the existing Hydro access roads.

B. Winter roads

Communities which are isolated by land from other parts of the province due to the absence of an all-weather road connection but which require a large volume of supplies may not be adequately served by aircraft alone. It is possible to construct roads over the frozen swamp, bog and/or lakes in the winter to such communities in order to provide accessibility by tractor train and/or truck. The winter roads constructed in this manner may, depending on the length of the winter and local terrain, provide as much as three months of service to the larger isolated communities (Map III provides information on freeze-thaw dates) enabling a large volume of necessary freight to be shipped to these settlements at rates lower than most normal air freight rates.

Initial government policy with regard to the construction, maintenance and licensing of these winter roads was to allow an individual shipper at a nominal fee of $1.00 per mile to build and maintain such roads for his own private use. To help reduce freight costs to isolated northern communities, the Province began assisting private freighters in 1968 to construct and maintain winter roads. This assistance was increased in subsequent years until in the winter of 1971-72 the entire cost of construction and maintenance was paid by the Government of Manitoba. As of the winter of 1972-73, due to spiralling costs of constructing a complete winter road network, the Manitoba government has announced a policy of integrating a 500 mile winter road system with a series of aircraft land or ice landing strips as a reduced-cost alternative.

With regard to the situation in the Outlet Lakes area (Map VIII) in a Manitoba government news release dated December 14, 1972 Northern Affairs Minister Ron McBryde stated:

> A 60 mile truck road is to be built along the fifteenth base line from PTH 6, in the vicinity of Williams Lake, to Norway House. A 20 mile truck road will be built from Jenpeg to Cross Lake. These two winter roads are expected to provide the land accessibility required to the communities of Cross Lake and Norway House.

The winter road system in the Outlet Lakes area, as described above, has reflected the effect of the Hydro development by the route chosen to connect Cross Lake. In past years, the winter road to Cross Lake has been much longer, originating at Wabowden. As a result of the construction of an all-weather access road to the Jenpeg site, a much shorter winter road from Jenpeg to Cross Lake will link this community with the Provincial highway system. A further consequence of Hydro development to the winter road system may relate to ice formation. Both winter roads described earlier are required to cross a certain length of frozen lake or river: the PTH 6 - Norway House road in particular must cross an approximate 10 mile stretch of ice on Playgreen Lake. In order to enable such ice crossings to carry the weight of large trucks, the ice must be of adequate thickness or, alternatively, ice bridges must be constructed. Information concerning the effects of the Hydro development on ice formation on Playgreen Lake and in the vicinity of Cross Lake community is unavailable from any source at this time; therefore, the effects on winter roads of this factor can only be speculated upon. If the winter road system in this area continues to follow the present routes it would be desirable to identify the ramifications, if any, of ice formation after the Hydro development.

In addition to the Manitoba government winter roads, a private winter road, to be built by C.F.I., is proposed. It will intersect the Jenpeg access road approximately 15 miles from Jenpeg and parallel the C.N.R. line to The Pas (Map VIII). Its purpose is to provide access to timber stands in the berth granted to C.F.I. and to utilize 100 cord capacity trucks (which cannot be used on provincial highways or roads) to remove the timber. The alignment of this winter road is such that the ydro development will have no significant effect on it.

C. Railways

The Hudson Bay Branch of the Canadian National Railways links the Port of Churchill on Hudson Bay to the wheat lands of southern Saskatchewan. This line enters Manitoba from Saskatchewan just southwest of The Pas (Map IV).

From The Pas the line continues northeast to Churchill, with a 40 mile branch line to Thompson. Another line runs north of The Pas to Lynn Lake with branches west to Flin Flon and east to Chisel Lake.[1]

The primary use of the Hudson Bay Railway has been as a carrier of wheat to the salt water Port of Churchill for shipment by ocean-going vessel to the markets of Western Europe. Although the shipment of wheat to overseas markets continues to be the predominant function of this facility, in recent years resource activities such as those of the International Nickel Company mining operation at Thompson, have relied on the railway as a relatively inexpensive means of moving their products to the markets of the South.

The route of the railway as shown in Maps IV and VIII is such that it lies at the periphery of the Outlet Lakes study area. This location places the railway outside the zone of immediate physical effects of the Hydro development. To be more specific, the railway line is located well beyond the maximum flood contour line of the Jenpeg forebay; hence no flooding is expected. Embankment instability on the Hudson Bay Railway has been a major problem over its past 30 year history, leading to above-average maintenance costs, however, this condition is not expected to be aggravated by Hydro development.

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[1] Province of Manitoba Inquiry into Northern Transportation, 1969.

Despite its relative distance from the Hydro sites, Hydro development may have some significant operational effects on the Hudson Bay Railway. As mentioned, there is at present no railway branch line into the Outlet Lakes area. The closest railhead is at Wabowden at the northwest periphery. Assuming no branch line into the area is constructed in the near future, the Jenpeg access road would appear to provide the only all-weather surface connection between the area and the railway line for the inbound and outbound shipment of bulk cargo. A centre such as Wabowden could serve as a transhipment point for this movement. The feasibility of this integration of transportation modes, facilitated by the Hydro development, is discussed at a later stage of this report.

D. Navigation

(1) Navigation routes: The navigation routes on the Outlet Lakes are linked directly to marine transportation on Lake Winnipeg and also to the lower Nelson River route below Cross Lake. This water route has a historical background dating from the 17th century. Henry Kelsey in 1690,

Anthony Hinday in 1754 and Matthew Cocking in 1772 were among those who traversed this route. The Selkirk Settlers and other early prairie pioneers utilized this water route to provide access to the southern portion of Western Canada during the 19th century. Until the middle of the second decade of the 20th century, York boats provided freight service from Norway House to Cross Lake via the West Channel of the Nelson River. Subsequently service was provided by barge from Selkirk and Warren Landing to Whiskey Jack Portage, and thence by truck overland and by gasoline boat to Cross Lake. This is basically the route taken today for shipment of freight by water from Winnipeg or Selkirk to Cross Lake.

Any discussion of marine transport on the Outlet Lakes must of necessity be preceded by an initial examination of the navigation aspects of Lake Winnipeg and the Red River downstream of Winnipeg.

Passage on the Red River is limited to the upper reaches of the Lockport Dam impoundment just south of Winnipeg at St. Norbert. Most marine freight, however, is shipped from Selkirk downstream of the Lockport Dam.

Lake Winnipeg extends in a northwesterly direction for approximately 240 miles from the delta of the Red River. The average depths of the lake vary from 15 feet at the southern extremity to over 80 feet in the northern basin. The navigable depth of the Lake (excepting the Red River delta) is a minimum of 20 feet (which occurs in a short section of less than 2 miles in the Narrows area). At the outlet of Lake Winnipeg in the four mile approach to Warren Landing the lake bed profile ranges from approximately 10 to 30 feet.[1]

From Warren Landing on Playgreen Lake north to the Kiskittogisu Lake side of Whiskey Jack Portage (known as Whiskey Jack Landing) the navigable depth is a minimum of 6 feet. This minimum depth is also available in Kiskittogisu Lake. Whiskey Jack Landing is the northern terminus of marine transport in the Lake Winnipeg-Outlet Lakes system. For vessels with excessive draughts, such as the M.S. Lord Selkirk, Warren Landing is the northern most limit of navigation, and transhipment to smaller vessels is required for furtherance northward in years of low water levels. Map IX indicates the depths of channels along the navigation route.

The navigable depth on Lake Winnipeg and the Outlet Lakes depends to a certain extent on the amount of wind set up and other water level related influences. To illustrate, in the Playgreen Lakes area:

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[1] Manitoba Hydro, Engineering Division. Taken from a cross-section survey of the area conducted during the summer of 1971.

> ...with a strong north wind the water level drops and navigation is restricted (to Norway House), while with a strong south wind docks and piers (at Norway House) are frequently flooded.[1]

Weather conditions as well as season of year are therefore of prime importance to marine transport.

The length of the shipping season in the Lake Winnipeg-Outlet Lakes area is approximately 165 days. The mean break-up date is approximately May 20 and the mean freeze-up date is November 15 (Map III). Such conditions as current flow and warm water inflows may alter these dates on a local basis. As a further limitation to the length of the navigation season, the Royal Commission Inquiry into Northern Transportation notes that the availability of navigational aids together with the desirability of marine carriers to operate before and after the aforementioned dates, governs the length of the navigation season.

The local marine transportation system thus far considered can be extended to form a link in a water route from Winnipeg to Hudson Bay via the Nelson River (Map V). This route cannot at present be navigated due to the numerous rapids and the generating stations at Kelsey and Kettle Rapids which virtually close the channel to shipping of any kind. However, one must be cognizant that such a route to Hudson Bay is potentially available provided that channel improvements and locks were constructed and provided that such a route was economically viable.

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[1] Province of Manitoba Royal Commission Inquiry into Northern Transportation.

The length of navigation season on this extended route as determined by breakup and freeze-up dates, will be shortened considerably (in the order of 50 days) as compared to the local Lake Winnipeg to Outlet Lakes route.

Effects of Hydro development on navigation routes: As discussed in section IIIB, several physical changes will be made to the waterways in the Outlet Lakes area. These changes may have far-reaching effects on the navigation routes presently used in this area.

All three diversion channels: the Ominawin Bypass, the 8-Mile Channel and the 2-Mile Channel are to be maintained at a minimum depth of 25 feet. The minimum width on any of the Channels is 410 feet occurring on the 2-Mile Channel and the maximum width being 1,500 feet on the Ominawin Bypass. These factors, coupled with the increase in the depth (2 to 5 feet) of the West Channel due to the forebay created by Jenpeg, make the passage of vessels of 6 to 8 foot draught possible as far as the Jenpeg site itself. A lock at the Jenpeg structure would allow passage directly by boat from Selkirk or Winnipeg to Cross Lake community.

Of direct concern to navigation is the shoreline access which is allowed after regulation. The specific issue is the flooding of tree stands in proximity to the Jenpeg site. The Jenpeg forebay clearing specifications make reference to the following general terms which serve to provide accessibility to shoreline and remove obstructions to navigation.

(a) All merchantable timber i.e. trees of the 4-inch diameter or greater and more than 30 feet high size, will be cut.

(b) All islands will be cleared to the elevation of 715 feet.

(c) Steep banks will be cleared to elevation of 715 feet.

(d) Well defined river banks will be cleared to elevation of 713 feet.

(e) River banks with mild slopes where flooding is extensive will be cleared to elevation of 710 feet.

(f) Floodplains isolated by booms will be cleared to the booms.

(g) Clearing will take place up to dykes except for free board dykes.

(h) The Department of Tourism, Recreation and Cultural

Affairs Parks Branch has designated areas where docks and landings are located. These areas will be cleared and grubbed.

(i) Access to the shore is provided at relatively constant intervals of three miles. These areas will be designated during clearing operations by the contractor.

(j) An agreement between Manitoba Hydro and the Province of Manitoba provides for further clearing four years after project completion within a cost limit of one million dollars.

(2) Aids to navigation: Navigation aids on inland waters are operated by the Federal Ministry of Transport. The Federal Department of Public Works, Marine Branch, is responsible for the construction, maintenance and repair of these aids for the navigation of hazardous stretches of water such as shallow areas, narrow inlets or outlets, etc. At the present time navigational aids in the Outlet Lakes area are entirely situated in the immediate vicinity of Warren Landing. A list of these aids may be found in Table 1. The new channels which will be created by Hydro development in the Outlet Lakes area may possibly constitute an alteration in the existing navigation route (see previous section (1)). In that event, it may become necessary to install aids to navigation in these channels to provide

TABLE 1

NAVIGATIONAL AIDS IN OUTLAKES AREA

Name	Position	Description
Warren Landing Lower Range	On southwest end of Purvis Island, head of Nelson River Lat. N 53°42'54" Long. W 97°52'12"	White, fixed light; 32 ft. above high water; seen at 10 miles in clear weather; electric, reflector-type illuminating apparatus
Warren Landing Lower Range	033°30' 2,600 ft. from front	White, fixed light, 42 ft. above high water; seen at 11 miles in clear weather; electric, reflector-type illuminating apparatus
Warren Landing Upper Range	West side of entrance to Nelson River Lat. N 52°42'33" Long. W 97°53'26"	White, fixed light; 33 ft. above high water; electric, refractor-type illuminating apparatus
Warren Landing Upper Range	003°40' 836 ft. from front	White, fixed light; 42 ft. above high water; electric, reflector-type illuminating apparatus
Warren Landing Light Buoy	Lat. N 52°37'15" Long. W 97°58'10"	White, flashing light; electric; radar reflector

Source: Government of Canada, Ministry of Transport, List of Lights, Buoys and Fog Signals, Inland Waters, West of Montreal and East of British Columbia, 1972.

for safe passage of marine vessels. At present, no specific information as to the actual necessity for lights and/or buoys for these channels is available.

(3) Marine freight facilities: An integral part of any marine transportation system is adequate facilities to provide the necessary means by which goods are loaded and unloaded. Major facilities of this nature in the Outlet Lakes area include those at Warren Landing, Norway House, Whiskey Jack Portage and Cross Lake, all of which will be discussed below along with an assessment of the possible effects to these facilities of the Hydro development.

Warren Landing: This community serves as a possible transhipment point for goods from the south which are destined for the Norway House or Cross Lake area. Any vessel with too great a draught is unable to navigate further than Warren Landing and must transfer its goods to smaller boats during periods of low water levels. The structure at Warren Landing is a wharf constructed by the Federal Department of Public Works andiits deck elevation is 718.00 feet.

Since the elevation of the deck is at least three feet above the maximum regulated level of 715 feet[1] the wharf structure at Warren Landing will not undergo flooding as a result of the regulation of Lake Winnipeg.

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[1] Water Resources Branch Report on Water Levels.

One possible effect of Hydro development on the wharf at Warren Landing is not easily quantifiable. That is the possible abandonment of the marine facilities at this community in favour of using the 2-Mile Channel which will be dredged by Hydro to improve the flow of Lake Winnipeg water into Playgreen Lake. This channel will permit marine vessels to bypass the dangerous, shallow area, which is in the immediate vicinity of Warren Landing, when entering the Outlet Lakes. The result of this abandonment of the Warren Landing route may be that the wharf facilities will be used as a shelter when Lake Winnipeg is impassable due to storms.

Norway House: Norway House serves as a supply centre for isolated communities such as Oxford House, Garden Hill and Shamattawa. It receives goods by barge for reshipment by air to these settlements.

There are two major marine freight handling facilities in Norway House, on Fort Island and at Rossville on the mainland. The wharf on Fort Island, which was built by the Province, also includes a large warehouse in the process of completion. There is a road connection from this facility to the mainland which facilitates easier distribution of local commodity requirements. The deck elevation of this wharf is approximately 717 feet elevation and as such should be unaffected by flooding as a result of regulation.

The wharf at Rossville was constructed by the Federal Department of Public Works and consists of two levels: the upper level is at an elevation of 717 feet while the lower level has an elevation of 714.3 feet. This seems to indicate that in times of high water under regulated conditions, the lower section of the facility could be flooded to a depth of up to approximately 0.7 feet while the upper section will not be affected. Therefore, if the lower section of the wharf is going to continue to be utilized, raising the level of the deck might be warranted.

Due to the absence of any definite information regarding the construction of a control structure on the East Channel of the Nelson River, no comment as to the effect of such a structure on the marine facilities at Norway House is possible.

Whiskey Jack Portage: The Whiskey Jack Portage serves as the means by which goods bound for Cross Lake community are transported to bypass the unnavigable stretches of the Nelson River, West Channel. The wharves, built by the Federal Department of Public Works, are on both the Kiskittogisu and Cross Lake sides of the portage. The

Kiskittagisa Lake wharf has a deck elevation of 713.5 feet and therefore could be flooded at times of high water, after regulation, to a depth of up to 1.5 feet. On the Cross Lake side, the wharf deck level is 685.0 feet which is slightly lower than the regulated maximum level of 685.9[1] and thus may be subject to periodic wash.

It is therefore apparent that, due to the distinct possibility of the flooding of both wharves at both ends of the Whiskey Jack Portage, these facilities must either be raised to a level above the maximum flood line after regulation or some other alternative must be found.

Cross Lake: The major marine freight handling facility at Cross Lake community is the Hudson's Bay Company dock on the east shore of the Nelson River. However, information about this facility is sketchy. Its deck elevation is approximately 688.0 feet and as such will not be flooded. There are other, smaller private docking facilities in the community but no information is available with regard to their elevation.

Approach depth: No information has been provided regarding the approach depths in the vicinity of the docks and wharves mentioned above. The mean monthly minimum of 711.0 feet on Lake Winnipeg and the Outlet Lakes above Jenpeg and 674.9 feet on Cross Lake may impair the approach of larger boats to dock facilities where the present depth is not excessive. No conclusions on this matter can be reached without the necessary information.

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[1] Water Resources Branch Report on Water Levels.

E. Sea plane landing bases

Float equipped aircraft or sea planes are used extensively in the North during the summer months. They augment the service provided by standard wheeled aircraft or are the sole source of air service for communities which lack an adequate airstrip. In the Outlet Lakes area sea plane service is provided to Norway House and Cross Lake (Map X) as a supplement to the wheeled aircraft services.

(i) Norway House: The landing site at Norway House includes an area west of Forestry Island which has four approaches: N-S:1.6 miles, NE-SW:1.7 miles, NNE-SSW:7.0 miles, E-W:1.7 miles, at latitude 53°59'N, longitude 97°50'W. The base is operated jointly by Manitoba Government Air Services and Lambair. The usable time span is from breakup to freeze-up on approximately May 31 and October 31 respectively.

Due to the fact that the Norway House sea plane base is located in the area upstream of the Jenpeg control structure, the water levels will normally vary from elevation 711 feet to 715 feet. The mean average water level, historically, at Norway House is approximately 712 feet. Therefore, since the regulated levels will be very close to the mean historical level, the fluctuations caused by the Jenpeg control structure will have no forseeable effect on the sea plane base. However, if a control structure is constructed on the East Channel, the situation with regard to this base may be altered. It is not possible to determine the degree of alteration in the water level fluctuations or flow patterns at Norway House. Since information as to the exact location of the proposed East Channel control structure is not available, any comment concerning the effects of this structure on the sea plane base at Norway House would be pure speculation.

(2) Cross Lake: The landing area is located at latitude 54°37'N, longitude 97°47'W, in front of the Hudson's Bay Company post and south of the Roman Catholic mission. The orientation of the landing site is north-south, approximately 1 mile in length and is confined by many island outcrops in the Nelson River. The site is also subject to variations in currents. The landing base is operated by Cross Lake Airways with a serviceable time of usage between approximately April 10 and November 1.

The sea plane base will not be affected by maximum and minimum levels on Cross Lake under regulated conditions but by the rate of fluctuation and the alterations in current flow. Water level fluctuations of less than maximum-minimum proportion (674.9 to 685.9) experienced after regulation may cause hazards to float equipped aircraft. The area presently used for landing, as described earlier, is of a confined nature and contains many islands and outcrops which may be totally or partially submerged in times of higher water, (greater than the historical average level of 679.0) creating reefs which are a danger to sea planes using this landing site. The current flow on Cross Lake may vary from a low of 25,000 cubic feet per second (cfs) to a high of 113,000 cubic feet per second, depending on the amount of water required for Hydro production at Jenpeg. A combination of high rate of flow and high levels may delay the freeze-up date or move the thaw date forward and thus extend the period of usage of the sea plane landing area. Conversely low flow coupled with low water levels will advance the date of freeze-up and/or break-up and hence reduce the sea plane landing season.

The alteration in freeze-thaw dates will be made more difficult to predict by the construction of the Jenpeg and East Channel control structures since these control structures might alter the internal flow patterns on Cross Lake. A more detailed analysis of this condition is necessary before definite conclusions may be drawn. Such an analysis is outside the terms of reference of this study.

F. Airstrips

In the past decade, airstrips have become of increasing importance to the transportation system in the North. This emergence of air transportation as a major means of moving people and goods in and out of relatively remote areas of Northern Manitoba is reflected in present government policy. "By the end of 1972 the Manitoba government will have spent five million dollars on a major air transportation plan involving regional airports, airstrips and landing strips in the North. This development will see a gradual phasing out of historical winter tractor train operations in the North."[1]

The Outlet Lakes area contains two regular service airstrips at Norway House and Cross Lake, supplemented by an emergency landing strip at Warren Landing. Airstrips have also been constructed to service Hydro construction at Jenpeg and the 8-Mile Channel (Map X). A more detailed discussion of these airstrips coupled with the physical effect of the Hydro development in the Outlet Lakes area follows.

(1) Norway House: The airstrip at Norway House is operated by Manitoba Government Air Services and is classified

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[1] Manitoba Government News Release by Premier Edward Schreyer September 22, 1972.

under category VFR Day (Visual Flight Rules Day Time Use). It is located on Fort Island at latitude 53°53'N, and longitude 97°50'W northwest of the community and consists of a gravel runway 4,800 feet in length and at elevation 720 feet. At present there is emergency lighting only which, according to government sources, will be replaced by a permanent lighting system.[1] The facilities at the airdrome include hydro power and terminal shelters. A government dock constructed adjacent to the warehouse and airstrip also serves to integrate air and water transport, with Norway House serving as a distribution centre for Oxford House, Garden Hill and Shamattawa. There are access roads to the airstrip on Fort Island connecting with the community.

Little Playgreen Lake, on which Norway House is situated, will form a part of the Outlet Lakes-Lake Winnipeg reservoir after regulation. As stated in section IIIA, this water body is expected to fluctuate between elevations 711 to 715 feet, with the maximum level of 715 occurring on a more frequent basis than the historical maximum elevation of 717.6 feet. Since the airstrip is located at an elevation of 720 feet, which is well above the regulated maximum, no flooding of this facility is expected as a result of Hydro development.

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[1] Ibid.

(2) Cross Lake: The airstrip at Cross Lake is owned and operated by Manitoba Government Air Services. It is situated in the section known as the Mission Area on the Cross Lake expansion of the Nelson River at latitude 54°35'N, longitude 97°48'W. The elevation of the strip is 709 feet and it is 2,600 feet in length. The surface consists of a clay and gravel mixture which is unserviceable when wet. A terminal building is proposed for the strip but work on it has not yet been undertaken.

Accessibility to this airstrip, on the east shore of the Nelson River, consisists of a gravel road which extends north to the Saggitawa area of the community. On the Cross Island side of the Nelson River, the only accessibility to the airstrip is by barge, private boat or a pedestrian suspension bridge which is located at the south end of the community.

As indicated (section IIIA), under regulated conditions, Cross Lake is expected to fluctuate between elevation 679.9 feet and 685.9 feet, with extremes occurring on a 20 year cycle. However, fluctuations within these extremes are much more prevalent.

Since the airstrip is situated well above the maximum water level of elevation 685.9 feet (see above), no flooding of this facility is expected as a result of Hydro development. Indirect effects on the airstrip, however, may result, due to flooding of low portions of the access road which is below the 685.9 foot maximum elevation. The sections of the access road so affected, which would require raising total approximately 3,400 feet.[1]

(3) Warren Landing: The airstrip at Warren Landing is situated immediately to the west of the settlement at latitude 53°42'N, longitude 97°53'W. It is owned and operated on an emergency basis by Northland Freight and Forwarding Limited. The airstrip is located on generally swampy ground flanked by beach sands of fine graduation. Its usable length is 2,600 feet and it has been constructed of beach sand, several feet above the present Lake Winnipeg. water level.

No information more specific than this is available for the elevation of this airstrip. Consequently any comment on the effects of Hydro development cannot be substantiated and will not be included in the discussion.

(4) Jenpeg: This airstrip was built to service the construction site at Jenpeg and is operated by Manitoba Hydro. The runway is paved and is 2,500 feet in length. It is located at an elevation of approximately 727 feet on

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[1] M.M. Dillon, Cross Lake Transportation Report, 1971.

the west side of the Nelson River. At present it is equipped for daylight landing only and has an aircraft parking area. Accessibility from the construction site is provided by a branch of the Jenpeg access road.

Manitoba Hydro intends to use this airstrip to service the Jenpeg site on a continuing basis after construction has been completed. Since the airstrip is meant as a permanent facility and since it was built with the realization that the Jenpeg control structure would result in a certain amount of upstream flooding, it is reasonable to conclude that the strip has been located at an elevation (727 feet) which will leave it unaffected by its close proximity to the Jenpeg site.

(5) 8-Mile Channel: This airstrip was built to service the construction area along the 8-Mile Diversion Channel. It is composed of a soft sand and gravel mixture and is approximately 2,500 feet in length. An on-site inspection of the facility suggested that it was approximately 20 feet above the present water level and on the northeast side of the channel site near the Playgreen Lake inlet. The strip is usable only in dry weather and during daylight hours. In view of its elevation, it is unlikely that the airstrip will be affected by flooding as a result of regulation.

(6) Other projects: With the continuation of construction of Hydro facilities in the Outlet Lakes area, such as the Kiskitto Dam and associated works, the East Channel control structure and the 2-Mile Channel, additional airstrips and/or sea plane landing areas may be required to service these construction sites. Since no specific information exists with regard to these potential landing areas they will not be discussed further in this report.

V EFFECTS OF HYDRO DEVELOPMENT ON RESOURCE TRAFFIC

This section of the report examines the method of transporting existing and potential resource base traffic from the Outlet Lakes area to its destination. Alternative methods of removal facilitated by Hydro development as a result of modifications to the existing transportation infrastructure are considered. An analysis of the costs which result from the removal of the major resources (i.e. fisheries and forestry) is included.

A. Commercial fisheries

(1) Production: A major resource and export of the Outlet Lakes area is fish. This industry provides employment on a regular basis for many of the local residents of Cross Lake and Norway House. The major fishing regions which will be discussed are in the area of Cross Lake and Norway House. The Cross Lake area fishery includes the following lakes:

(a) Cross Lake:

Seasonal nature: summer

Total fish catch (1971): 101,065 pounds

Species of fish: Pickerel, Whitefish, Pike

Value to fisherman (at lakeside): $29,230.17

Limit on lake: 100,000 pounds

(b) North Playgreen Lake:

Seasonal nature: summer

Total fish catch (1971): 369.5 pounds

Species of fish: Trout

Value to fishermen: $217.00

Limit on lake: 5,000 pounds

(c) Pipestone Lake:

Seasonal nature: winter

Total fish catch (1971-72): 10,048 pounds

Species of fish: Whitefish, Pickerel, Pike

Value to fishermen: $3,320.02

Limit on lake: 30,000 pounds

(d) Walker Lake:

Seasonal nature: summer and winter

Total fish catch (1971-72): 59,853 and 6,600 pounds

Species of fish: Pickerel, Pike, Whitefish

Value to fishermen: Unavailable and $864.60

Limit on lake: 85,000 pounds

(e) Kiskittogisu Lake:

Seasonal nature: summer

Total fish catch (1971): 16,322 pounds

Species of Fish: Pickerel, Whitefish, Pike

Value to fishermen: Unavailable

Limit on lake: 50,000 pounds

(f) Kiskitto Lake:

Seasonal nature: summer and winter

Species of fish: Pickerel, Whitefish, Goldeye

Limit on lake: 30,000 and 30,000 pounds

The Norway House area fishery includes:

(a) South Playgreen Lake:

Seasonal nature: summer

Total fish catch (1971): 331,041 pounds

Species of fish: Whitefish, Pickerel, Pike, Tullibee, Perch

Value to fishermen: $119,898.84

Limit on lake: 250,000 pounds

(2) Distribution: The relatively isolated northern fisheries such as those in the Outlet Lakes area are subject to comparatively high transportation costs which reduce the returns to the fishermen in these areas.

Cross Lake Area: The present method of removing the fish caught in the lakes in the area of Cross Lake is by chartered aircraft to Wabowden and from there by truck or rail to Winnipeg. Shipment by rail is subject to inefficiency both in terms of time of haul as well as in time used in transhipment. The effect of excessive handling time causes some deterioration in the quality of fish and its subsequent market value, especially if the air delivery service to Wabowden does not coincide with the regular rail service to Winnipeg.

The construction of the Jenpeg access road (again a direct result of Hydro development) and the possible extension of this road to Cross Lake would eliminate the extra handling at Wabowden, if by truck, and speed up the delivery to Winnipeg. Until the extension is completed, a shuttle service to Jenpeg from Cross Lake by air or refrigerated barge (in summer) could be employed. The increased depth of the West Channel of the Nelson River as a result of the Jenpeg control structure,ccoupled with the Diversion Channels and a possible lock in the Jenpeg structure, would enable fish from Cross Lake to be transported by barge directly to Selkirk or Winnipeg. Although the shipment time may be increased over the existing method, direct shipment by barge would eliminate handling time and subsequently reduce deterioration of the cargo.

The following series of tables and the graph indicate the cost differential for various modes and weights of fish shipments from the Cross Lake area.

TABLE VA1

OUTBOUND CARGO

Method 1:

Origin: Cross Lake Final destination: Winnipeg

Lakes included: Cross, Pipestone, North Playgreen, Kiskittogisu, Kiskitto and Walker

Type of cargo: Fish

Mode(s) of transport: Truck

Linkage(s) and mode(s) used: Cross Lake to Winnipeg via Jenpeg access road, possible extension and PTH 6

Seasonal nature: Winter and summer

Weight (cwt)	Truck Unit Rate $/cwt	Total cost $
240	3.00	720
400	3.00	1200
500	3.00	1500
700	3.00	2100
800	3.00	2400
1100	3.00	3300
1400	3.00	4200
1700	3.00	5100
2000	3.00	6000
2300	3.00	6900

Limit on lakes in 1971 was 2200 cwt.
Total fish catch in 1971 was 1596.52 cwt.

Note: The truck rate of $3.00 includes refrigeration-heating service

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VA2

OUTBOUND CARGO

Method 2:

Origin: Cross Lake Final destination: Winnipeg

Lakes included: Cross, Pipestone, North Playgreen, Kiskitto and Walker

Type of cargo: Fish

Mode(s) of transport: Rail and truck

Linkage(s) and mode(s) used: Cross Lake to Wabowden (using possible road from Jenpeg to Cross Lake) by truck and Wabowden to Winnipeg by rail

Seasonal nature: Winter and summer

Weight (cwt)	Truck		Rail		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
240	3.00	720	2.45	587	1307
400	3.00	1200	2.45	979	2179
500	3.00	1500	2.45	1222	2722
700	3.00	2100	2.45	1712	3812
800	3.00	2400	2.45	1960	4360
1100	3.00	3300	2.45	2690	5990
1400	3.00	4200	2.45	3430	7630
1700	3.00	5100	2.45	4160	9260
2000	3.00	6000	2.45	4900	10900
2300	3.00	6900	2.45	5620	12520

Limit on above lakes in 1971 was 2200 cwt.
Total fish catch in 1971 was 1596.52 cwt.

Rate Sources: Manitoba Department of Industry and Commerce and Canada Department of the Environment.

TABLE VA3

OUTBOUND CARGO

Method 3:

Origin: Cross Lake Final destination: Winnipeg

Lakes included: Cross, Pipestone, North Playgreen, Kiskitto and Walker

Type of cargo: Fish

Mode(s) of transport: Air and rail

Linkage(s) and mode(s) used: Cross Lake to Wabowden by air and Wabowden to Winnipeg by rail

Seasonal nature: Summer only

Weight (cwt)	Air		Rail		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
240	3.00	720	2.45	587	1307
400	3.00	1200	2.45	979	2179
500	3.00	1500	2.45	1222	2722
700	3.00	2100	2.45	1712	3812
800	3.00	2400	2.45	1960	4360
1100	3.00	3300	2.45	2690	5990
1400	3.00	4200	2.45	3430	7630
1700	3.00	5100	2.45	4160	9260
2000	3.00	6000	2.45	4900	10900
2300	3.00	6900	2.45	5620	12520

Limit on above lakes in 1971 was 2200 cwt.
Total fish catch in 1971 was 1596.52 cwt.

Rate Source: Ibid.

TABLE VA4

OUTBOUND CARGO

Method 4:

Origin: Cross Lake Final destination: Winnipeg

Lakes included: Cross, Pipestone, North Playgreen, Kiskitto and Walker

Type of cargo: Fish

Mode(s) of transport: Air and truck

Linkage(s) and mode(s) used: Cross Lake to Wabowden by air and Wabowden to Winnipeg by truck

Seasonal nature: Summer only

Weight (cwt)	Air		Truck		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate ¢/lb.	Subtotal $	
240	3.00	720	2.50	600	1320
400	3.00	1200	2.50	1000	2200
500	3.00	1500	2.50	1250	2750
700	3.00	2100	2.50	1750	3850
800	3.00	2400	2.50	2000	4400
1100	3.00	3300	2.50	2750	6050
1400	3.00	4200	2.50	3500	7700
1700	3.00	5100	2.50	4250	9350
2000	3.00	6000	2.50	5000	11000
2300	3.00	6900	2.50	5750	12650

Limit on above lakes in 1971 was 2200 cwt.
Total fish catch in 1971 was 1596.52 cwt.

The truck rate of $2.50/cwt was estimated from the Winipeg-Norway House rate of $3.00/cwt including refrigeration-heating.

Rate Sources: Ibid.

TABLE VA5

OUTBOUND CARGO

Method 5:

Origin: Cross Lake Final destination: Selkirk

Lakes included: Cross, Pipestone, North Playgreen, Kiskitto and Walker

Type of cargo: Fish

Mode(s) of transport: Barge

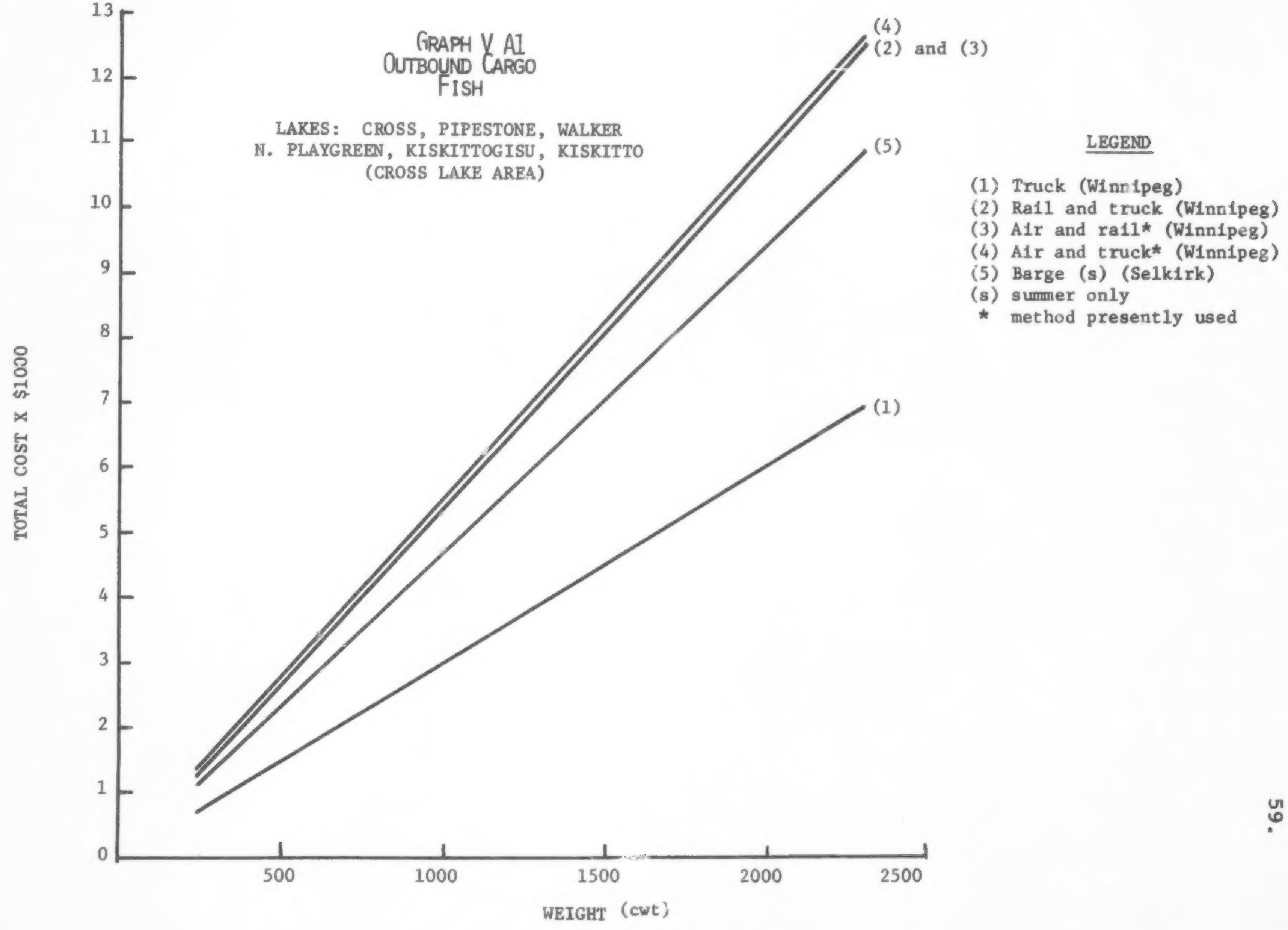
Linkage(s) and mode(s) used: Cross Lake to Selkirk (Winnipeg) by barge using possible lock at Jenpeg, Ominawin Bypass, 8-Mile Channel and 2-Mile Channel

Seasonal nature: Summer

Weight (cwt)	Barge Unit Rate $/cwt	Total Cost $
240	4.75	1140
500	4.75	2375
800	4.75	3800
1100	4.75	5225
1400	4.75	6650
1700	4.75	8075
2000	4.75	9500
2300	4.75	10925

Limit on above lakes in 1971 was 2200 cwt.
Total fish catch in 1971 was 159,652 pounds.

Rate Sources: Marine Transport Limited, M.M. Dillon Report.



GRAPH V A1
OUTBOUND CARGO
FISH

LAKES: CROSS, PIPESTONE, WALKER
N. PLAYGREEN, KISKITTOGISU, KISKITTO
(CROSS LAKE AREA)

Transportation cost analysis of Cross Lake area fisheries

Method 1:

Movement of fish by truck on all-weather road via the Jenpeg access road and its possible extension to Cross Lake community and PTH6 to Winnipeg.

1. Hydro inputs available:
    (a) Jenpeg access road
    (b) Jenpeg control structure bridgehead
2. Hydro inputs required: Nil
3. Other inputs required:
    (a) Jenpeg access road extension to Cross Lake.
4. General shipping cost for potential traffic (annual):
    Limit: 2200 cwt Cost: $6600.00
5. Rank of method:
    First out of five methods.
6. Hydro development impact on method:
    Hydro development has a major beneficial impact on the potential utilization of this method, having provided the greatest portion of the infrastructure in the Outlet Lakes area necessary for removal.

Method 2:

Movement of fish by truck on all-weather road via the Jenpeg access road and its possible extension to Cross Lake, transshipment at Wabowden to rail and then to Winnipeg.

1. Hydro inputs available:
   (a) Jenpeg access road
   (b) Jenpeg control structure bridgehead
2. Hydro inputs required: Nil
3. Other inputs required:
   (a) Jenpeg access road extension to Cross Lake
4. General shipping cost for potential traffic (annual):
   Limit: 2200 cwt Cost: $12,000.00
5. Rank of method:
   Third out of five methods (tied).
6. Hydro development impact on method:
   Similar to method one.

Method 3:

Cross Lake to Wabowden by float equipped aircraft, transshipment to rail for furtherance to Winnipeg (summer only).

1. Hydro inputs available: Nil
2. Hydro inputs required: Nil
3. Other inputs required: Nil
4. General shipping cost for potential traffic (annual):
   Limit: 2200 cwt Cost: $12,000.00
5. Rank of method:
   Third out of five methods (tied).

6. Hydro development impact on method:

   Hydro development does not affect this method of removal.

Method 4:

Cross Lake to Wabowden by float equipped aircraft, transshipment to truck for furtherance to Winnipeg (summer only).

1. Hydro inputs available: Nil
2. Hydro inputs required: Nil
3. Other inputs required: Nil
4. General shipping cost for potential traffic (annual)

   Limit: 2200 cwt Cost: $12,100.00
5. Rank of method:

   Fifth out of five method.
6. Hydro development impact of method:

   Same as method three.

Method 5:

Cross Lake to Selkirk or Winnipeg by barge or boat using a possible lock in the Jenpeg structure, Ominawin Bypass, 8-Mile Channel and 2-Mile Channel (summer only).

1. Hydro inputs available:
   - (a) Jenpeg control structure
   - (b) Ominawin Bypass
   - (c) 8-Mile Channel

(d) 2-Mile Channel

2. Hydro inputs required:

   (a) Right of way for lock in Jenpeg structure

3. Other inputs required:

   (a) Jenpeg control structure lock

4. General shipping cost for potential traffic (annual):

   Limit: 2200 cwt   Cost: $10,400.00

5. Rank of method:

   Second out of five methods.

6. Hydro development impact on method:

   Hydro development has a major beneficial impact on the potential utilization of this method, since it has provided or will be providing the channel improvments necessary as an initial stage in its availability.

Norway House area: The present method of removing the fish caught in South Playgreen Lake in the area of Norway House is by barge direct to Selkirk or Winnipeg.

In a similar manner to its effect on the Cross Lake fishery, the Jenpeg access road could alter the distribution pattern of fish from the Norway House area lakes with the proviso that this road is extended to Norway House. This would mean that fish could be loaded on trucks at Norway House for direct shipment to Winnipeg via Jenpeg.

A more immediate effect of Hydro development is to provide the existing barge operation to Selkirk with an alternate route via the 2-Mile Channel, thus bypassing Warren Landing.

Tables VA6 to VA11 and the accompanying graph illustrate the removal of fish from South Playgreen Lake by various modes.

TABLE VA6

OUTBOUND CARGO

Method 1:

Origin: Norway House Final destination: Winnipeg

Lakes included: South Playgreen, Little Playgreen

Type of cargo: Fish

Mode(s) of transport: Truck

Linkage(s) and mode(s) used: Norway House to Winnipeg via Jenpeg access road and possible extension and PTH6

Seasonal nature: Summer and winter

Weight (cwt)	Truck Unit Rate $/cwt	Total Cost $
240	3.00	720
500	3.00	1500
1000	3.00	3000
1500	3.00	4500
2000	3.00	6000
2500	3.00	7500
3000	3.00	9000
3500	3.00	10500

Limit on lakes in 1971 was 3000 cwt.
Total fish catch in 1971 was 3447.54 cwt.

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VA7

OUTBOUND CARGO

Method 2:

Origin: Norway House Final destination: Winnipeg

Lakes included: South Playgreen, Little Playgreen

Type of cargo: Fish

Mode(s) of transport: Truck and rail

Linkage(s) and mode(s) used: Norway House to Wabowden using possible Jenpeg-Norway House road by truck and Wabowden to Winnipeg by rail

Seasonal nature: Summer and winter

Weight (cwt)	Truck		Rail		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
240	3.00	720	2.45	587	1307
400	3.00	1200	2.45	980	2180
500	3.00	1500	2.45	1222	2722
700	3.00	2100	2.45	1715	3815
800	3.00	2400	2.45	1960	4360
1100	3.00	3300	2.45	2690	5990
2000	3.00	6000	2.45	4900	10900
2500	3.00	7500	2.45	6120	13620
3000	3.00	9000	2.45	7350	16350
3500	3.00	10500	2.45	8570	19070

Limit on above lakes in 1971 was 3000 cwt.
Total fish catch in 1971 was 3447.54 cwt.

Rate Sources: Manitoba Department of Industry and Commerce and Canada Department of the Environment.

TABLE VA8

OUTBOUND CARGO

Method 3:

Origin: Norway House Final destination: Winnipeg

Lakes included: South Playgreen, Little Playgreen

Type of cargo: Fish

Mode(s) of transport: Air and truck

Linkage(s) and mode(s) used: Norway House to Wabowden by air and Wabowden to Winnipeg by truck (PTH6-PR391)

Seasonal nature: Summer

Weight (cwt)	Air		Truck		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
240	4.70	1128	2.50	600	1728
500	4.70	2350	2.50	1250	3600
1000	4.70	4700	2.50	2500	7200
1500	4.70	7050	2.50	3750	10800
2000	4.70	9400	2.50	5000	14400
2500	4.70	11750	2.50	6250	18000
3000	4.70	14100	2.50	7500	21600
3500	4.70	16450	2.50	8750	25200

Limit on above lakes in 1971 was 3000 cwt.
Total fish catch in 1971 was 3347.54 cwt.

Rate Sources: Ibid.

TABLE VA9

OUTBOUND CARGO

Method 4:

Origin: Norway House Final destination: Winnipeg

Lakes included: South Playgreen, Little Playgreen

Type of cargo: Fish

Mode(s) of transport: Air and rail

Linkage(s) and mode(s) used: Norway House to Wabowden by air and Wabowden to Winnipeg by rail

Seasonal nature: Summer

Weight (cwt)	Air		Rail		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
240	4.70	1128	2.45	588	1716
400	4.70	1880	2.45	980	2860
500	4.70	2350	2.45	1224	3574
700	4.70	3290	2.45	1715	5005
800	4.70	3760	2.45	1960	5720
1000	4.70	4700	2.45	2450	7150
2000	4.70	9400	2.45	4900	14300
2500	4.70	11750	2.45	6120	17870
3000	4.70	14100	2.45	7350	21450
3500	4.70	16450	2.45	8570	25020

Limit on above lakes in 1971 was 3000 cwt.
Total fish catch in 1971 was 3447.54 cwt.

Rate Sources. Ibid.

TABLE VA10

OUTBOUND CARGO

Method 5:

Origin: Norway House Final destination: Selkirk

Lakes included: South Playgreen, Little Playgreen

Type of cargo: Fish

Mode(s) of transport: Barge

Linkage(s) and mode(s) used: Norway House to Selkirk by barge

Seasonal nature: Summer

Weight (cwt)	Barge	
	Unit Rate $/cwt	Total Cost $
240	4.75	1140
500	4.75	2375
1000	4.75	4750
1500	4.75	7125
2000	4.75	9500
2500	4.75	11875
3000	4.75	14250
3500	4.75	17000

Limit on above lakes in 1971 was 3000 cwt.
Total fish catch in 1971 was 3447.54 cwt.

Rate Sources: Marine Transport Limited.

TABLE VA11

OUTBOUND CARGO

Method 6:

Origin: Norway House Final destination: Winnipeg

Lakes included: South Playgreen, Little Playgreen

Type of cargo: Fish

Mode(s) of transport: Truck and winter truck

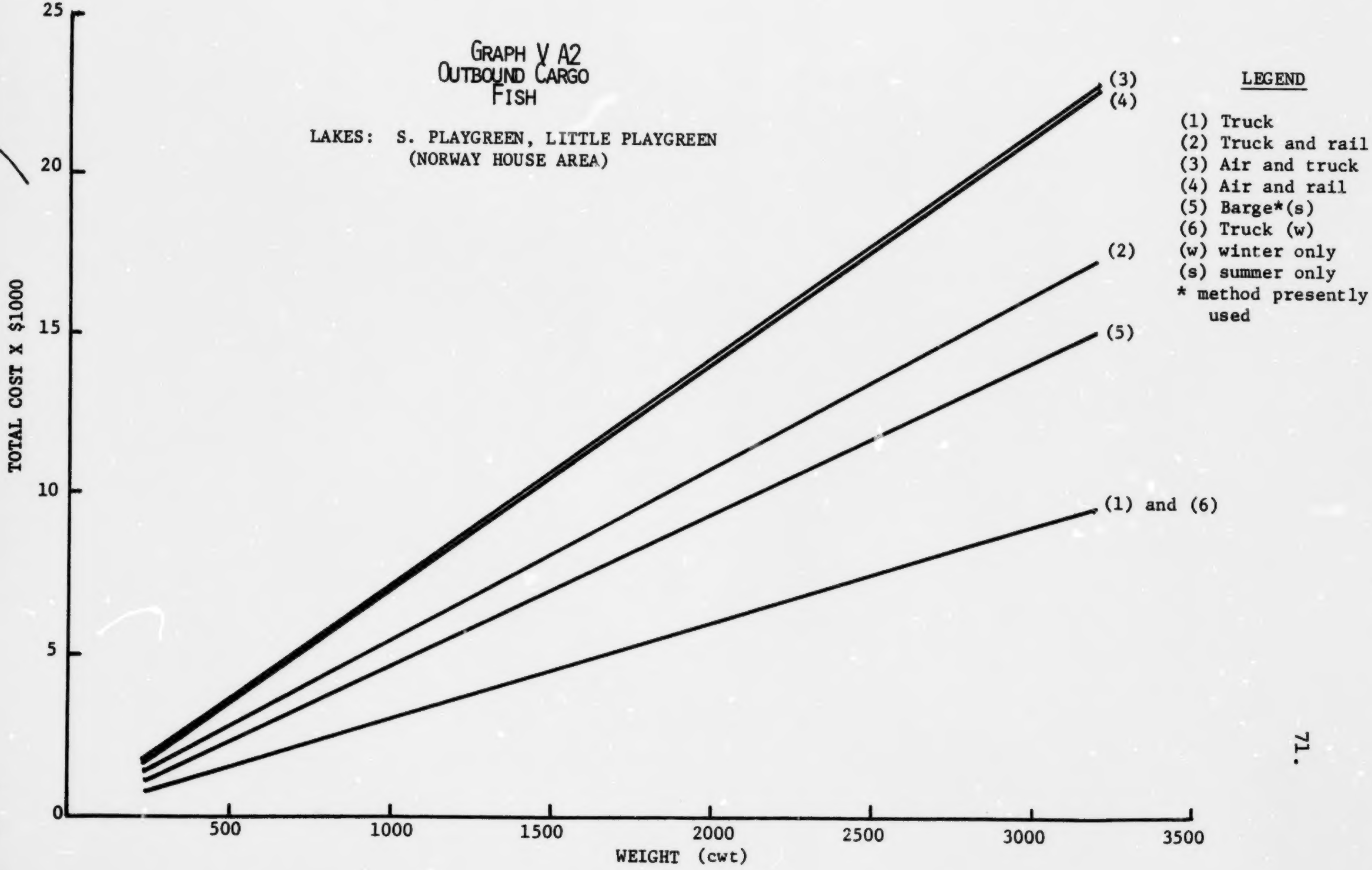
Linkage(s) and mode(s) used: Norway House to PTH6 by winter truck road, PTH6 to Winnipeg by truck

Seasonal nature: Winter

Weight (cwt)	Winter Truck		Truck		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
240	1.00	240	2.00	480	720
500	1.00	500	2.00	1000	1500
1000	1.00	1000	2.00	2000	3000
1500	1.00	1500	2.00	3000	4500
2000	1.00	2000	2.00	4000	6000
2500	1.00	2500	2.00	5000	7500
3000	1.00	3000	2.00	6000	9000
3500	1.00	3500	2.00	7000	10500

Limit on above lakes in 1971 3000 cwt.
Total fish catch in 1971 3447.54 cwt.

Rate Source: Manitoba Department of Industry and Commerce.



GRAPH V A2
OUTBOUND CARGO
FISH

LAKES: S. PLAYGREEN, LITTLE PLAYGREEN
(NORWAY HOUSE AREA)

Transportation cost analysis of Norway House area fisheries

Method 1:

Movement of fish by truck on all-weather road, via the Jenpeg access road and its possible extension to Norway House via PR391 and PTH6 to Winnipeg.

1. Hydro inputs available:
   - (a) Jenpeg access road
   - (b) Jenpeg control structure bridgehead
2. Hydro inputs required:
   - (a) Jenpeg access road extension to the East Channel control structure
   - (b) East Channel control structure bridgehead
3. Other inputs required:
   - (a) East Channel control structure road connection to Norway House
4. General shipping cost for potential traffic (annual):

   Limit: 3000 cwt Cost: $9000.00
5. Rank of method:

   First out of six methods (tied)
6. Hydro development impact on method:

   Hydro development has a major beneficial impact on the potential utilization of this method, having provided the greatest portion of the infrastructure in the Outlet Lakes area necessary for this removal.

Method 2:

Norway House to Wabowden by truck via Jenpeg access road and possible Norway House extension, transshipment at Wabowden to rail for furtherance to Winnipeg.

1. Hydro inputs available:
   (a) Jenpeg access road
   (b) Jenpeg control structure bridgehead
2. Hydro inputs required:
   (a) Jenpeg access road extension to the East Channel control structure
   (b) East Channel control structure road connection to Norway House
4. General shipping cost for potential traffic (annual):
   Limit: 3000 cwt Cost: $16,350.00
5. Rank of method:
   Fourth out of six methods
6. Hydro development impact on method:
   Same as method one.

Method 3:

Norway House to Wabowden by float-equipped aircraft, transshipment to rail for furtherance to Winnipeg (summer only).

1. Hydro inputs available: Nil
2. Hydro inputs required: Nil

3. Other inputs required: Nil
4. General shipping cost for potential traffic (annual):

   Limit: 3000 cwt Cost: $21,600.00
5. Rank of method:

   Sixth out of six methods
6. Hydro development impact on method:

   Hydro development does not affect this method of removal.

Method 4:

Norway House to Wabowden by float-equipped aircraft, transshipment to rail for furtherance to Winnipeg (summer only).

1. Hydro inputs available: Nil
2. Hydro inputs required: Nil
3. Other inputs required: Nil
4. General shipping cost for potential traffic (annual):

   Limit: 3000 cwt Cost:
5. Rank of method:

   Fifth out of six methods
6. Hydro development impact on method:

   Hydro development does not affect this method of removal.

Method 5:

Norway House to Selkirk or Winnipeg by barge using the 2-Mile Channel (summer only).

1. Hydro inputs available:

   (a) 2-Mile Channel

2. Hydro inputs required: Nil

3. Other inputs required: Nil

4. General shipping cost for potential traffic (annual):

   Limit: 3000 cwt Cost: $14,250.00

5. Rank of method:

   Third out of six methods

6. Hydro development impact on method:

   Hydro development has some beneficial impact on the potential utilization of this method, since it provides the 2-Mile Channel for access from Playgreen Lake to Lake Winnipeg bypassing the hazardous Warren Landing approach.

Method 6:

Norway House to PTH6 by truck using the winter road along the 15th base line, and then by truck using PTH6 to Winnipeg (winter only).

1. Hydro inputs available: Nil

2. Hydro inputs required: Nil

3. Other inputs required: Nil

4. General shipping cost for potential traffic (annual):

   Limit: 3000 cwt Cost: $9000.00

5. Rank of method:

First out of six methods (tied).

6. Hydro development impact on method:

Hydro development does not affect this method appreciably.

B. Forestry

The forestry products industry, producing pulpwood and lumber, provides another export of the Outlet Lakes area. The entire province is divided into forest management areas, in order to facilitate systematic removal of the product and sustained yield of the resources. The two management areas which include all of the Outlet Lakes area are numbers 82 and 83 (Map XII).

(1) Forest Management Area 82:

i) Production: This Management unit contains almost all of the Outlet Lakes area with the exception of a portion of the East and West Channels of the Nelson River and Cross Lake. The total yearly potential production is estimated at 26,000 to 27,000 cords of pulpwood. There are three distinct sub-areas (shown on Map XII) which may potentially produce most of the forest products in this management area. The first lies to the northwest of Kiskittogisu Lake. The second is situated between Playgreen Lake and Kiskittogisu Lake. The third sub-area is east of Norway

House. Of the total yearly potential production, the first two sub-areas together may account for about 10,000 to 15,000 cords, while the third sub-area may account for approximately 12,000 to 17,000 cords. The present operation in the area consists of approximately 5,000 cords per year.[1]

ii) Modes of transport: Marine Transport Company has the cutting rights in this area. They are under contract to the Abitibi Manitoba Paper complex at Pine Falls to cut and transport the pulpwood. Since Marine Transport Company is a water based operation, the movement of pulpwood to Abitibi takes place only in the summer months when Lake Winnipeg is navigable. Some of the lumber in Management Area 82 is used to supply local demand at Norway House, where a sawmill is in operation.

As a result of the Hydro development, the areas of potential production will possibly become more easily accessible. The resource to the northwest of Kiskittogisu Lake may be removed via the newly constructed Hydro access road built to service the Ominawin Bypass construction site which follows the west shore of the Nelson as far south as the Ominawin area and connects to the Jenpeg access road. Shipment of pulpwood to The Pas may be made by all-weather road directly or by transshipment from the Jenpeg access road to rail at Pipun or Wabowden. Direct accessibility to the potential forestry areas northwest of Kiskittogisu Lake would be provided by the construction of the Kiskitto control dam and the associated access road (see section IVA4). With the integration of a short rafting operation, this land bridge at the Kiskitto Dam would also facilitate removal of forestry products in the area between Lakes Kiskittogisu and Playgreen. Another possibility for removal of forest products from this area would be by utilizing the 8-Mile Channel at the south end of Kiskittogisu Lake. The pulpwood could be barged from the Kiskittogisu Lake area via the 8-Mile and possibly the 2-Mile Channel to Lake Winnipeg and Pine Falls. The potential production which exists in the area between Playgreen Lake and Kiskittogisu Lake may be removed by land and water in a similar manner to the above due to the close proximity of the two sub-areas.

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[1] Department of Mines, Resources and Environmental Management, Forestry Branch

The pulpwood to the east of Norway House could be removed by one of three methods: by loading on barges and shipment to Pine Falls, by truck to The Pas (C.F.I.) if a road from Jenpeg to Norway House was constructed or by a combination of truck and rail, again to The Pas. The latter two methods would of necessity be predicated upon the alteration of the present contract between Marine Transport

And Abitibi Manitoba Paper, to allow for shipment to The Pas as opposed to Pine Falls.

The cost of removing the potential forest products from Area 82 will vary with volume and mode used. The tables and graphs illustrate the cost differential of this removal for various volumes and modes for shipment by water south to Pine Falls and by road or rail to The Pas.

TABLE VB1

OUTBOUND CARGO

Method 1:

Origin: Forest Management Area 82 (Norway House area)

Final destination: The Pas

Type of cargo: Pulpwood

Mode(s) of transport: Truck

Linkage(s) and mode(s) used: Norway House to PR391 (including possible road from Jenpeg to Norway House) by truck and to The Pas by truck

Seasonal nature: Summer and winter

Weight (cwt)	Truck to PR391		Truck to The Pas		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
80000	.15	12000	.35	28000	40000
140000	.15	21000	.35	49000	70000
240000	.15	36000	.35	84000	120000
320000	.15	48000	.35	112000	160000
400000	.15	60000	.35	140000	200000
480000	.15	72000	.35	168000	250000
540000	.15	81000	.35	189000	270000
640000	.15	96000	.35	224000	320000

Estimated yearly potential yield: 15000 cords (600000 cwt)

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VB2

OUTBOUND CARGO

Method 2:

Origin: Forest Management Area 82 (Norway House area)

Final destination: The Pas

Type of cargo: Pulpwood

Mode(s) of transport: Truck and rail

Linkage(s) and mode(s) used: Norway House to Wabowden (including possible road from Jenpeg to Norway House) by truck and to The Pas by rail

Seasonal nature: Summer and winter

Weight (cwt)	Truck to Wabowden		Rail to The Pas		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
80000	.15	12000	.15	12000	24000
140000	.15	21000	.15	21000	42000
240000	.15	36000	.15	36000	72000
320000	.15	48000	.15	48000	96000
400000	.15	60000	.16	60000	120000
480000	.15	72000	.15	72000	144000
540000	.15	81000	.15	81000	162000
640000	.15	96000	.15	96000	192000

Estimated yearly potential yield: 15000 cords (600000 cwt)

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VB3

OUTBOUND CARGO

Method 3:

Origin: Forest Management Area 82 (Norway House area)

Final destination: Pine Falls

Type of cargo: Pulpwood

Mode(s) of transport: Barge

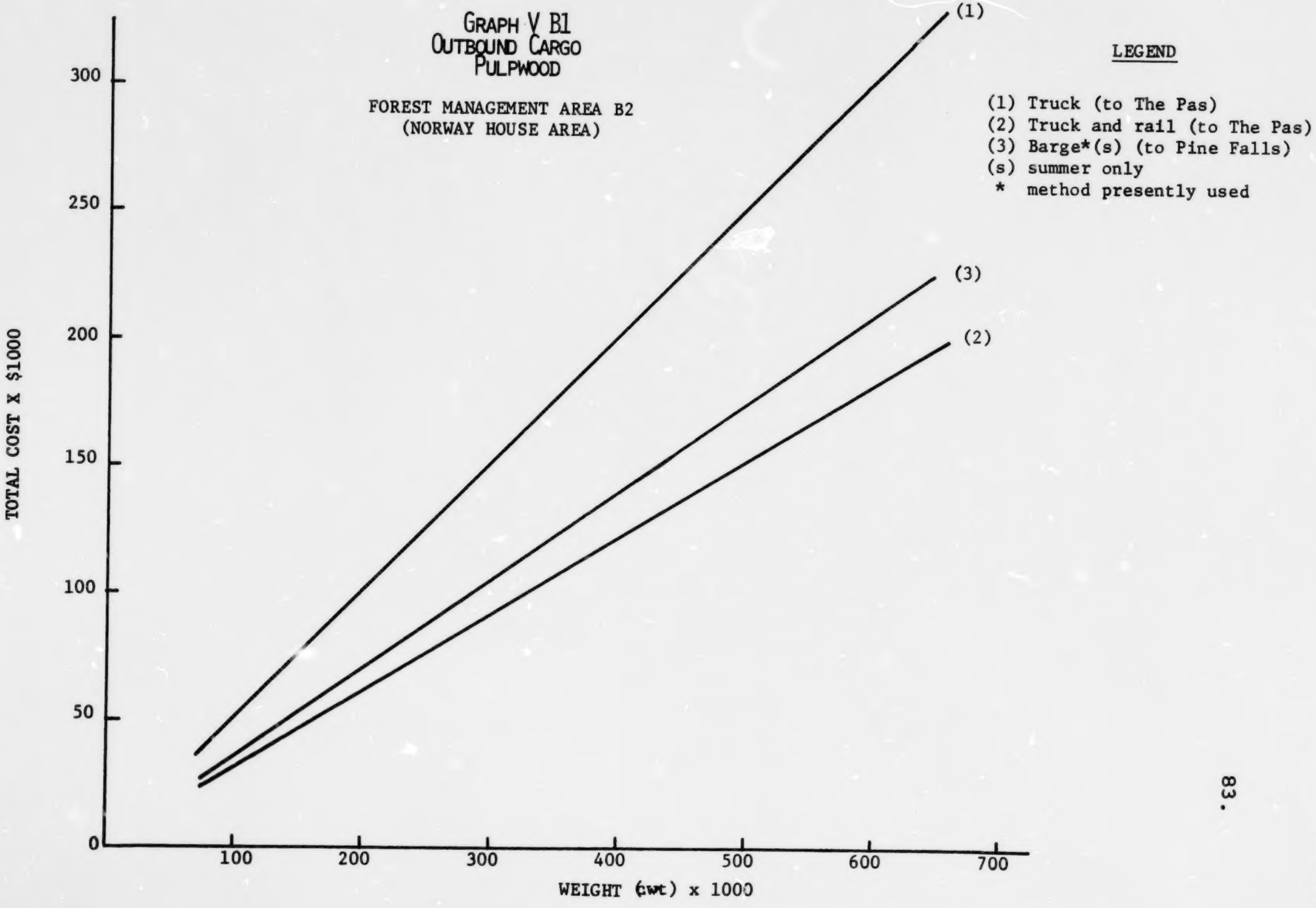
Linkage(s) and mode(s) used: Norway House area to Pine Falls via barge.

Seasonal nature: Summer

Weight (cwt)	Barge	Total Cost $
	Unit Rate $/cwt	
80000	.35	28000
140000	.35	49000
240000	.35	84000
320000	.35	112200
400000	.35	140000
480000	.35	168000
540000	.35	189000
640000	.35	224000

Estimated yearly potential yield: 15000 cords (600000 cwt)

Rate Source: Marine Transport Limited



GRAPH V B1
OUTBOUND CARGO
PULPWOOD

FOREST MANAGEMENT AREA B2
(NORWAY HOUSE AREA)

Transportation cost analysis of Norway House area forest products

Method 1:

Norway House area to PR391 (including a possible road from Jenpeg to Norway House) and hence to The Pas by truck.

1. Hydro inputs available:
   (a) Jenpeg access road
   (b) Jenpeg control structure bridgehead
2. Hydro inputs required:
   (a) East Channel control structure bridgehead
   (b) Access road to East Channel control structure from Jenpeg
3. Other inputs required:
   (a) All-weather road from the East Channel control structure to Norway House
   (b) Forestry feeder roads in the area east of Norway House
4. General shipping cost for potential traffic (annual):

   Limit: 600000 cwt Cost: $300,000
5. Rank of method:

   Third out of three methods.
6. Hydro development impact on method:

   Hydro development would have a major beneficial impact on this means of resource product removal due to its providing the bulk of the infrastructure in the Outlet

Lakes area required for this removal.

Method 2:

Norway House area to Wabowden (including a possible road from Jenpeg to Norway House) by truck for transshipment to rail and furtherance to The Pas.

1. Hydro inputs available:
    - (a) Jenpeg access road
    - (b) Jenpeg control structure bridgehead
2. Hydro inputs required:
    - (a) East Channel control structure bridgehead
    - (b) Access road to East Channel control structure from Jenpeg
3. Other inputs required:
    - (a) All-weather road from the East Channel control structure to Norway House
    - (b) Forestry feeder roads in the area east of Norway House
4. General shipping cost for potential traffic (annual):

    Limit: 600000 cwt Cost: $180,000
5. Rank of method:

    First out of three methods.
6. Hydro development impact on method:

    Similar to method one.

Method 3:

Norway House area to Pine Falls via barge (summer only).

1. Hydro inputs available:

   (a) 2-Mile Channel

2. Hydro inputs required: Nil

3. Other inputs required: Nil

4. General shipping cost for potential traffic (annual);

   Limit: 600000 cwt Cost: $210,000

5. Rank of method:

   Second out of three methods

6. Hydro development impact on method:

   Hydro development would have a minor beneficial impact on this method of removal due to the improvement of the navigation route (2-Mile Channel).

TABLE VB4

OUTBOUND CARGO

Method 1:

Origin: Forest Management Area 82 (Kiskittogisu Lake area)

Final destination: The Pas

Type of cargo: Pulpwood

Mode(s) of transport: Truck

Linkage(s) and mode(s) used: Kiskittogisu Lake area to PR391 (including possible road from Jenpeg to Kiskitto Dam site) by truck and to The Pas by truck

Seasonal nature: Summer and winter

Weight (cwt)	Truck to PR391		Truck to The Pas		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
200000	.15	30000	.35	70000	100000
280000	.15	42000	.35	98000	140000
400000	.15	60000	.35	140000	200000
480000	.15	72000	.35	168000	250000
600000	.15	90000	.35	210000	300000
720000	.15	108000	.35	262000	370000
800000	.15	120000	.35	280000	400000
880000	.15	132000	.35	308000	440000

Estimated yearly potential yield: 20000 cords (800000 cwt)

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VB5

OUTBOUND CARGO

Method 2:

Origin: Forest Management Area 82 (Kiskittogisu Lake area)

Final destination: The Pas

Type of cargo: Pulpwood

Mode(s) of transport: Truck and rail

Linkage(s) and mode(s) used: Kiskittogisu Lake area to Wabowden (including possible road from Jenpeg to Kiskitto Dam site) by truck and from Wabowden to The Pas by rail

Seasonal nature: Summer and winter

Weight (cwt)	Truck to Wabowden		Rail to The Pas		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
200000	.15	30000	.15	30000	60000
280000	.15	42000	.15	42000	84000
400000	.15	60000	.15	60000	120000
480000	.15	72000	.15	72000	144000
600000	.15	90000	.15	90000	180000
720000	.15	108000	.15	108000	216000
800000	.15	120000	.15	120000	240000
880000	.15	132000	.15	132000	264000

Estimated yearly potential yield: 20000 cords (800000 cwt)

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VB6

OUTBOUND CARGO

Method 3:

Origin: Forest Management Area 82 (Kiskittogisu Lake area)

Final destination: The Pas

Type of cargo: Pulpwood

Mode(s) of transport: Truck

Linkage(s) and mode(s) used: Kiskitto Lake area to The Pas by winter truck road

Seasonal nature: Winter

Weight (cwt)	Winter Truck	Total Cost $
	Unit Rate $/cwt	
200000	.70	140000
280000	.70	196000
400000	.70	280000
480000	.70	336000
600000	.70	420000
720000	.70	504000
800000	.70	560000
880000	.70	616000

Estimated yearly potential yield: 20000 cords (800000 cwt)

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VB7

OUTBOUND CARGO

Method 4:

Origin: Forest Management Area 82 (Kiskittogisu Lake area)

Final destination: Pine Falls

Type of cargo: Pulpwood

Mode(s) of transport: Barge

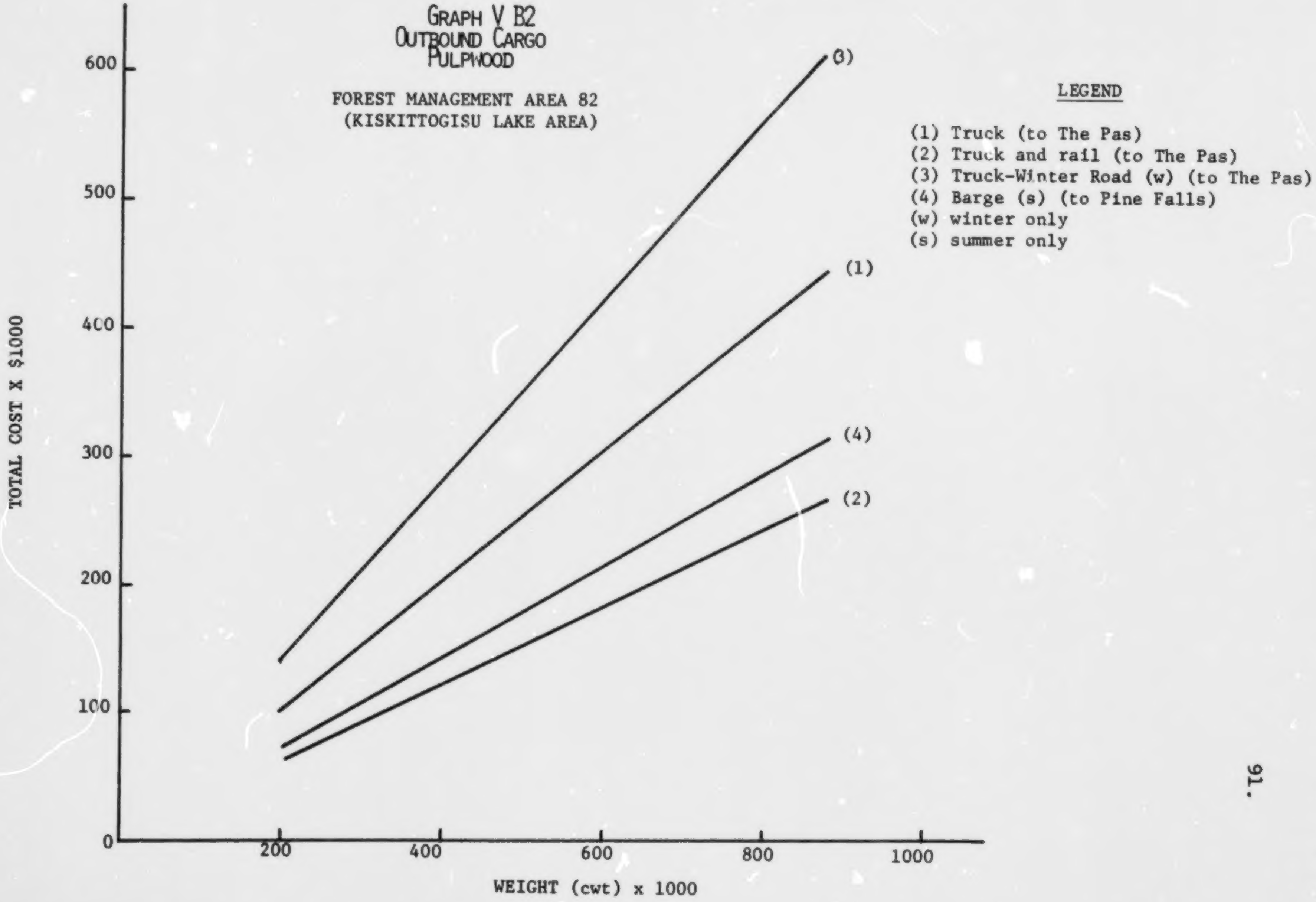
Linkage(s) and mode(s) used: Kiskittogisu Lake area via 8-Mile and 2-Mile Channels to Pine Falls

Seasonal nature: Summer

Weight (cwt)	Barge Unit Rate $/cwt	Total Cost $
200000	.35	70000
280000	.35	98000
400000	.35	140000
480000	.35	168000
600000	.35	210000
720000	.35	262000
800000	.35	280000
880000	.35	308000

Estimated yearly potential yield: 20000 cords (800000 cwt)

Rate Source: Marine Transport Limited.



GRAPH V B2
OUTBOUND CARGO
PULPWOOD

FOREST MANAGEMENT AREA 82
(KISKITTOGISU LAKE AREA)

LEGEND

(1) Truck (to The Pas)
(2) Truck and rail (to The Pas)
(3) Truck-Winter Road (w) (to The Pas)
(4) Barge (s) (to Pine Falls)
(w) winter only
(s) summer only

Transportation cost analysis of Kiskittogisu area forest products

Method 1:

Kiskittogisu Lake area to PR391 (including a possible road from Jenpeg to Kiskitto Dam site) and hence to The Pas by truck.

1. Hydro inputs available:
   (a) Jenpeg access road
   (b) Ominawin road extension from Jenpeg
   (c) Kiskitto Lake Dam - bridgehead
2. Hydro inputs required:
   (a) Extension of Ominawin road to Kiskitto Lake Dam bridgehead
3. Other inputs required:
   (a) Forestry feeder roads in the area
4. General shipping cost for potential traffic (annual):
   Limit: 800000 cwt Cost: $400,000
5. Rank of method:
   Third out of four methods
6. Hydro development impact on method:
   Hydro development has a major beneficial impact on the potential utilization of this method, having provided or possibly providing virtually all of the infrastructure in the Outlet Lakes area necessary for removal.

Method 2:

Kiskittogisu Lake area to Wabowden (including a possible road from Jenpeg to Kiskitto Dam site) by truck for transshipment to rail and furtherance to The Pas.

1. Hydro inputs available:
   - (a) Jenpeg access road
   - (b) Ominawin road extension from Jenpeg
   - (c) Kiskitto Lake Dame - bridgehead
2. Hydro inputs required:
   - (a) Extension of Ominawin road to Kiskitto Lake Dam bridgehead
3. Other inputs required:
   - (a) Forestry feeder roads in the area
4. General shipping cost for potential traffic (annual):

   Limit: 800000 cwt Cost: $240,000
5. Rank of method:

   First out of four methods
6. Hydro development impact on method:

   Similar to method one

Method 3:

Kiskitto Lake area to The Pas by winter truck road.

1. Hydro inputs available: Nil
2. Hydro inputs required: Nil

3. Other inputs required:
   (a) Extension of major C.F.I. winter road to Kiskittogisu Lake area
   (b) Forestry feeder roads in the area
4. General shipping cost for potential traffic (annual):

   Limit: 800000 cwt Cost: $560,000
5. Rank of method:

   Fourth out of four methods
6. Hydro development impact on method:

   Hydro development does not affect this method

Method 4:

Kiskittogisu Lake area by barge via 8-Mile and 2-Mile Channels to Pine Falls.

1. Hydro inputs available:
   (a) 8-Mile Channel
   (b) 2-Mile Channel
2. Hydro inputs required: Nil
3. Other inputs required:
   (a) Landing facilities for loading pulpwood onto barges
4. General shipping cost for potential traffic (annual):

   Limit: 800000 cwt Cost: $280,000
5. Rank of method:

   Second out of four methods

6. Hydro development impact on method:

Hydro development has a major beneficial impact on this method, providing the necessary navigational improvements (8-Mile and 2-Mile Channels) essential for utilization of this means of removal.

(2) Forest Management Area 83:

i) Production: Management Area 83 (Map XII) includes all of Cross Lake and the northern portions of the East and West Channels of the Nelson River. Most of the area delineated as 83 can be classed as having a marketable product although at the present time most of the area is not in production (the cutting rights are held by C.F.I.). The total estimated potential production is 115,000 to 120,000 cords per year of which about 2,000,000 board feet is expected to be used for lumber, the rest for pulpwood.[1]

ii) Modes of transport: The northern portion of Area 83 is presently serviced by Provincial Road 373 to Sipiwesk Lake and by the Hydson Bay Railway. There has been no new road construction in this area as a direct result of the Hydro development.

The access road which has been constructed to Jenpeg as a result of the Hydro development could serve as a means of removing the forest products in the southern portion of Area 83 with, if necessary, feeder roads branching north and south from the Jenpeg road to provide better accessibility to marketable timber stands.

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[1] Ibid.

A second means of removal which may be possible for the southern portion is by barge. As mentioned in section IVD, the control structure at Jenpeg will create a forebay of navigable depth permitting access by certain vessels to the Jenpeg site which coupled with the Ominawin Bypass, 8-Mile and 2-Mile Channels, will provide a water route south to Lake Winnipeg. However, the fact that the contract to cut timber in Area 83 is held by C.F.I., whose headquarters are at The Pas, may preclude using this marine route.

Section IVB mentions the possible construction of a winter truck road extending from The Pas (paralleling the Hydson Bay Railway) to a point of intersection with the Sipiwesk Lake road, now called Provincial Road 373, in the Outlet Lakes area. This winter road, if constructed, will allow C.F.I. to tap the forest resource of Management Area 83 where it now has cutting rights.

Because of the great distance of this area from the C.F.I. complex at The Pas, (at a radius of approximately 160 miles) shipment of forest products by conventional land vehicles would be expensive. As a result, C.F.I. plans to use a truck with a capacity of 100 cords per load to ship over this long distance at the lowest unit cost. Weight restrictions on the Provincial highways exclude this enormous vehicle from the existing network, hence use of the proposed winter road. Crossing rights at Provincial roads have been guaranteed through an agreement between C.F.I. and the Province.

A set of cost comparison tables and a graph similar to that for Area 82 have been prepared for Area 83 for various modes and volumes of pulpwood.

TABLE VB8

OUTBOUND CARGO

Method 1:

Origin: Forest Management Area 83 (Cross Lake area)

Final destination: The Pas

Type of cargo: Pulpwood

Mode(s) of transport: Truck

Linkage(s) and mode(s) used: Cross Lake area to PR391 (using possible Jenpeg-Cross Lake road) and PR391 to The Pas by truck

Seasonal nature: Summer and winter

Weight (cwt)	Truck to PR391		Truck to The Pas		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
800000	.15	120000	.35	280000	400000
1600000	.15	240000	.35	560000	800000
2400000	.15	360000	.35	840000	1200000
3200000	.15	480000	.35	1120000	1600000
4000000	.15	600000	.35	1400000	2000000
4800000	.15	720000	.35	1680000	2400000
5600000	.15	840000	.35	1960000	2800000

Estimated yearly potential yield: 120000 cords (4800000 cwt)

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VB9

OUTBOUND CARGO

Method 2:

Origin: Forest Management Area 83 (Cross Lake area)

Final destination: The Pas

Type of cargo: Pulpwood

Mode(s) of transport: Truck and rail

Linkage(s) and mode(s) used: Cross Lake area to Wabowden (using possible Jenpeg-Cross Lake road) by truck and Wabowden to The Pas by rail

Seasonal nature: Summer and winter

Weight (cwt)	Truck to Wabowden		Rail to The Pas		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
800000	.15	120000	.15	120000	240000
1600000	.15	240000	.15	240000	480000
2400000	.15	360000	.15	360000	720000
3200000	.15	480000	.15	480000	960000
4000000	.15	500000	.15	600000	1200000
4800000	.15	720000	.15	720000	1440000
5600000	.15	840000	.15	840000	1680000

Estimated yearly potential yield: 120000 cords (4800000 cwt)

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VB10

OUTBOUND CARGO

Method 3:

Origin: Forest Management Area 83 (Cross Lake area)

Final destination: Pine Falls

Type of cargo: Pulpwood

Mode(s) of transport: Barge

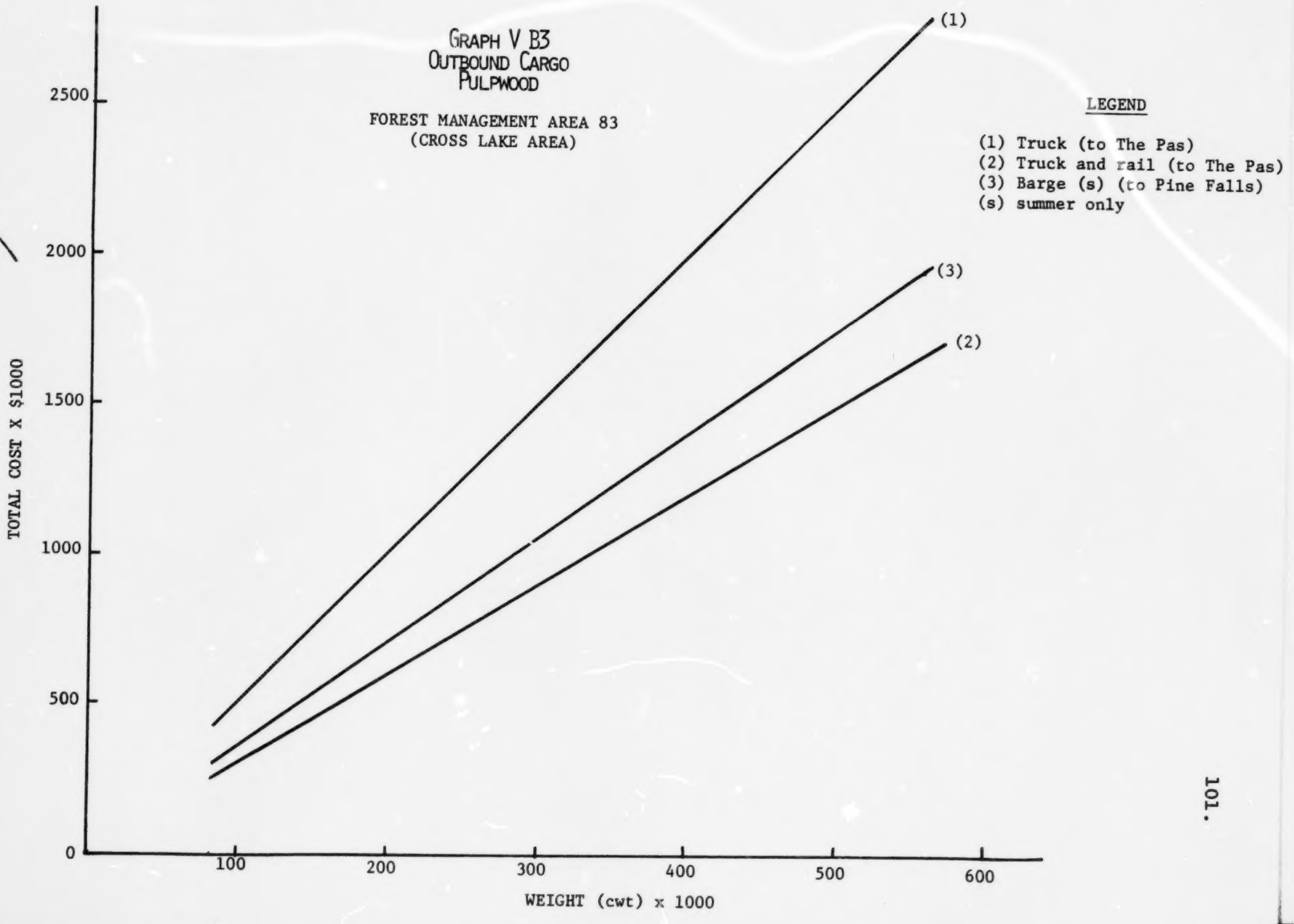
Linkage(s) and mode(s) used: Cross Lake vai possible lock at Jenpeg, the Ominawin Bypass, 8-Mile and 2-Mile Channels to Pine Falls

Seasonal nature: Summer

Weight (cwt)	Barge	Total Cost $
	Unit Rate $/cwt	
800000	.35	280000
1600000	.35	560000
2400000	.35	840000
3200000	.35	1120000
4000000	.35	1400000
4800000	.35	1680000
5600000	.35	1960000

Estimated yearly potential yield: 120000 cords (4800000 cwt)

Rate Source: Marine Transport Limited.



GRAPH V B3
OUTBOUND CARGO
PULPWOOD

FOREST MANAGEMENT AREA 83
(CROSS LAKE AREA)

Transportation cost analysis of Cross Lake area forest products

Method 1:

Cross Lake area to PR391 (including a possible Jenpeg-Cross Lake raod) and hence to The Pas by truck.

1. Hydro inputs available:
    - (a) Jenpeg access road
    - (b) Jenpeg control structure - bridgehead
2. Hydro inputs required: Nil
3. Other inputs required:
    - (a) Jenpeg access road extension to Cross Lake
4. General shipping cost for potential traffic (annual):

   Limit: 4800000 cwt Cost: $2,400,000
5. Rank of method:

   Third out of three methods
6. Hydro development impact on method:

   Hydro development has a major beneficial impact on the potential utilization of this method, having provided the greatest portion of the infrastructure in the Outlet Lakes area necessary for removal.

Method 2:

Cross Lake area to Wabowden (including a possible Jenpeg-Cross Lake road) by truck for transshipment and furtherance to The Pas by rail.

1. Hydro inputs available:
    - (a) Jenpeg access road
    - (b) Jenpeg control structure - bridgehead
2. Hydro inputs required: Nil
3. Other inputs required:
    - (a) Jenpeg access road extension to Cross Lake
4. General shipping cost for potential traffic (annual):

   Limit: 4800000 cwt Cost: $1,440,000
5. Rank of method:

   First out of three methods
6. Hydro development impact on method:

   Similar to method one.

Method 3:

Cross Lake area via possible lock at Jenpeg, Ominawin Bypass, 8-Mile Channel and 2-Mile Channel to Pine Falls.

1. Hydro inputs available:
    - (a) Jenpeg control structure
    - (b) Ominawin Bypass
    - (c) 8-Mile Channel
    - (d) 2-Mile Channel
2. Hydro inputs required:
    - (a) Provision for a lock in the Jenpeg structure

3. Other inputs required:

   (a) Lock in the Jenpeg control structure

4. General shipping cost for potential traffic (annual):

   Limit: 4800000 cwt Cost: $1,680,000

5. Rank of method:

   Second out of three methods.

6. Hydro development impact on method:

   Hydro development has a major beneficial impact on this method, providing the necessary navigational improvements (Ominawin Bypass, 8-Mile and 2-Mile Channels) necessary for utilization of this removal method.

C. Recreation

This section examines the interrelatedness of potential outdoor activities and transportation in the Outlet Lakes region. Much of the information regarding potential recreation sites resulted from discussion with members of the Department of Tourism and Recreation, Parks Branch (also contracted to the Study Board). No attempt has been made to delineate the benefit-cost aspects of recreation in this area due to the vertual impossibility of quantifying (within the terms of reference of this study) the value placed on the type of passive outdoor recreational activities foreseen. This discussion is limited to potential recreation sites due to the fact that no outdoor recreation development and tourism on an organized bases are presently in existence in the area. Attention is focused on investigation of the transportation requirements of these potential sites and the effect of Hydro development on these requirements.

The areas which have been identified as potential recreation sites are (Map XIV):

(1) That area located on the East Channel of the Nelson River, downstream of Sea River Falls, hereafter referred to as the East Channel area.

(2) The northeast shore of Kiskitto Lake from Black Duck Creek east to the Nelson River, West Channel.

(3) The terminus of Provincial Road 373 at Sipiwesk Lake.

(1) East Channel area: This area will contain the only stretch of the Nelson River which remains in a natural state, free of man-made obstruction. This is even more significant in view of the fact that a portion of this area, including the inlet of the Echiamamish River, served

as a historical navigation route during the pioneer era of the West. It is characterized by certain unique physical features which identify it as a prime passive recreation area. To cite examples: the area contains a series of rapids which enhance its attractiveness; downstream of Sugar Falls the channel is braided and contains a variety of flora; several stretches of high rock outcrop dominate the topography. It may be noted that the area from Sea River Falls north to Sugar Falls is of lesser importance, as a result of the burned-out landscape. The above characteristics for the area downstream of Sugar Falls have established it as suitable for a particular type of activity according to the Parks Branch. This activity may be described as of a passive nature, that is to say, activity having little impact on the ecology of the area. The most obvious example of this type of activity is use of this waterway for canoeing. Since the prime interest as described earlier is to maintain this area as a wilderness park, accessibility would appear to be of secondary importance. At the present time there is no access by all-weather road to this area. Any future expansion of the highway system into the surrounding area should provide only minimum accessibility and not encroach on the wilderness concept. This may rule out any consideration of utilizing the east shore of the East Channel north of Sea River Falls for road construction purposes.

Due to the construction of the access road to Jenpeg, the possibility of an all-weather connection to Cross Lake has been proposed as discussed in section IVA5. Of the methods of connection possible only one would seem to fall within the limited access framework discussed above, a direct connection from Jenpeg via causeway or bridge to Cross Lake. Other possible alternatives are:

(1) a route via an East Channel control structure, or

(2) along the south shore of Cross Lake with a connecting ferry service.

Each of the latter alternatives would have a portion of its right-of-way directly encroaching the area designated as wilderness park.

Also as a possible result of the Hydro development, more specifically the proposed East Channel control structure, a connection from Jenpeg to Norway House via a crossing at the control structure may be considered for various reasons (discussed in section IVA4). The effects on the wilderness park concept of such a connection would be considerable unless proper consideration is given to the limited access nature of this recreation area. Therefore, this road connection should follow a route which is reasonably far removed from the East Channel to a point at which the actual crossing is made. The control structure located at Sea River Falls would provide the river crossing required as well as enabling the limited access to the recreation area desired due to the nature of the wilderness development.

(2) Northeast shore of Kiskitto Lake: This site is located in an isolated area with no present access by all-weather road. The closest road is Provincial Trunk Highway 6 approximately 25 miles to the west. The closest settlement is Cross Lake which is about 25 miles to the northeast. This area contains moderate tree growth, a number of beaches and has been identified as a prime water fowl hunting area due to its close proximity to the marshy feedgrounds along the southern shore of Kiskitto Lake.

The Hydro regulation scheme calls for maintenance of Kiskitto Lake at its historical levels (elevation 695 feet) in part by construction of a drainage channel to Black Duck Creek (Kiskitto-Minago Diversion Channel) as discussed in section IIIC. This may result in a potential canoe route from the Cross Lake area up the Minago River via Black Duck Creek to Kiskitto Lake. Such a route has certain aesthetic attractions due to its meandering channel, variable flora along the shore line and the absence of rapids. Apart from the above mentioned potential canoe route, the Hydro development is not seen as affecting the recreation potential of this area.

Air accessibility by float equipped plane will be difficult due to the shallow depth of the lake and numerous rock outcrops. This would seem to place prime importance on a road connection either by direct access via Provincial Trunk Highway 6 or by extension of the Jenpeg access road southward. Any future improvements in accessibility to this area, however, are subject to the decision as to whether or not it will be developed for recreation and if so, what regions it will serve. The Jenpeg access road now extends approximately 8 miles south of Jenpeg following the West Channel shoreline.

(3) Sipiwesk Lake - Terminus Provincial Road 373

This is a minor recreation area which is being developed as a wayside rest for sport fishermen utilizing Sipiwesk Lake. It is at present readily accessible from Provincial Road 391 via Provincial Road 373. Its location is such that it is on the fringe of the Outlet Lakes study area and by virtue of this fact it appears to be unaffected by the Hydro development.

The above discussion of the recreation potential of the Outlet Lakes area has been qualitative in its approach as opposed to the transportation cost analysis utilized in the other sections devoted to resource base considerations. This qualitative approach was undertaken due to the paucity of information with respect to recreation demand for these potential areas. A detailed recreation study however, is a prerequisite to any quantitative investigation of the transportation aspects of this resource base.

D. Mining and mineral potential

Unlike other regions of the North, the Outlet Lakes area is virtually void of any extensive mining activity. The one exception is the Falconbridge nickel mining operation in the vicinity of the town of Wabowden. Since this operation at Manibridge is at the periphery of the Outlet Lakes area and, as such, is far removed from the Hydro development, no beneficial or deleterious effects are forseen as a result of this development.

With regard to mineral potential, the Manitoba Department of Mines, Resources and Environmental Management, Mines Branch, jointly with the Canada Department of Energy, Mines and Resources, Mineral Resources Branch, has conducted an in-depth geological survey of the Outlet Lakes area as part of an overall study of the Canadian Shield in Manitoba. The potential for mineral extraction in much of the area was found to be less than in many other regions of the province. However, there appears to be a certain amount of potential nickel resource in the area immediately to the west of the West Channel of the Nelson River (approximately 100,000 to 200,000 tons) and in the vicinity of Cross Lake community (approximately 50,000 to 100,000 tons). There is also a potential gold resource on the north-central section of Ross Island (estimated at five to ten million dollars in value) and in the area of Cross Lake community (ten to twenty-five million dollars estimated)[1] (Map XIII).

In view of the speculative nature of mining activity, it would be difficult to assess the prospect of mineral exports in the same manner as fish or forestry products. Any opinion regarding the effect of mining discoveries on transportation as modified by the Hydro development can only be made subsequent to a substantial discovery in the area. At this time no such assessment is warranted.

E. Fur trapping

Historically, fur trapping has been a primary industry in the North. It is a highly unstable source of income, however, due to the fluctuation in demand for fur products on the world market. According to the Royal Commission Inquiry into Northern Transportation (1969):

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[1] The Undiscovered Mineral Endowment of the Canadian Shield in Manitoba, A. Azis, G.S. Barry and J. Haugh, 1972.

> "While expansion may be anticipated during the next 20 years, it is unlikely that there will be any significant change in the nature or scope of the fur industry in Manitoba."

With regard to the Outlet Lakes area, both Cross Lake community and Norway House serve as points to which furs are brought, from outlying trap lines, for shipment south to Winnipeg. As the weight of the fur pelts is very small, in comparison to other goods, most shipments are made by air or a combination of air and rail. From Cross Lake, the furs are shipped by air to Wabowden and then by rail to Winnipeg. Furs collected at Norway House are shipped to Winnipeg directly by air.

The Hudson's Bay Company, a major fur handler, has provided the following rates for fur shipment:

(a) Cross Lake - Winnipeg: 8 cents per pound by air to Wabowden and approximately 2½ to 3 cents per pound by rail to Winnipeg.

(b) Norway House - Winnipeg: 14 cents per pound by air direct to Winnipeg.

Since the value of furs to the trapper are subject to market demand fluctuations, there is no representative average value that can be given. Figures available for the 1970-71 fur trapping season indicate a total value to the trappers of $26,671.35 for furs collected at Cross Lake and $36,560.93 for furs collected at Norway House.[1]

An indepth analysis of transportation costs for this industry is not deemed necessary due to the relatively small amounts shipped. As a corollary to this, the small amounts shipped, in comparison to the overall outbound movement of other resource products, will not in itself generate an improvement in the accessibility to the area. Those improvements in accessibility initially resulting from Hydro development and extended to provide service to certain major resource areas or communities may, as an indirect consequence, serve as a removal method for furs. Fur trapping in itself therefore would not generate the extension. An example of this is the Jenpeg access road. If a land connection was established with Cross Lake community, such a road could be used to transport furs. However, the transporting of furs by road would not be a prime consideration in building such a connection.

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[1] Manitoba Department of Mines, Resources and Environmental Management.

VI TRANSPORTATION SERVICES TO THE COMMUNITIES

This section of the report deals with the service aspects of transportation, as it affects the communities of the Outlet Lakes area. The communities examined are Norway House, Cross Lake and Warren Landing and emphasis will be placed on existing transportation services and the possible alterations to these services as a result of Hydro development.

A. Transportation of people

(1) Intraregional travel: The main intraregional personal travel pattern is between Norway House and Cross Lake. There are three possible methods of travel on this route, two of which are seasonal being restricted to the summer and winter periods respectively. The first is by small boat or canoe from Norway House to Whiskey Jack Landing, along Whiskey Jack Portage to the Cross Lake side and again by small boat to Cross Lake. An alternative route is along the East Channel via Pipestone Lake to Cross Lake community. This method presupposes a trip purpose primarily that of pleasure since the time involved in undertaking such an excursion would be prohibitive if expediency was of prime concern. A second means of travel on

the Cross Lake-Norway House route, is by winter road either as a part of a winter tractor train or in individual bombardiers. This method is also quite slow and somewhat prohibitive as many tractor trains do not allow passengers and since few individual bombardiers are available for each journey. The third, and by far most popular means of intra-regional travel is by aircraft either charter or regularly scheduled flight by Midwest Airlines which flies daily except Sunday between Cross Lake and Norway House (Table 2).

The Hydro development in the Outlet Lakes area will have little foreseeable effect on either winter travel or travel by air. Only small boat travel may possibly be altered. The control structure at Jenpeg will, as mentioned in the previous sections, create a forebay which may be navigable by small craft. This fact coupled with the Ominawin Bypass (to be built) will result in access to Cross Lake via a very short portage at the Jenpeg control structure, eliminating the Whiskey Jack Portage route. A control structure on the East Channel would present a small obstruction to canoes travelling between Norway House and Cross Lake, necessitating a portage.

According to the operator of M&S Freighters at Cross Lake, the causeway crossing the Minago River (part of the

Jenpeg access road) has become an obstruction to canoeists or operators of small motor boats who use the Minago River for access to trap lines and fishing at Hill Lake.

(2) Inter-regional travel: It is difficult to ascertain the main inter-regional personal travel patterns to and from the Outlet Lakes to the rest of Manitoba and Canada. It will, therefore, be necessary to concentrate on the existing routes by various modes to and from this area which lead primarily in a north-south direction.

Due to the lack of land access to this area, the present primary mode of egress and ingress is the airplane. Both Norway House and Cross Lake are serviced by a six day per week Midwest Airlines flight from Winnipeg while Norway House alone is serviced by Cambrian and Trans Air, and Cross Lake has air access to Wabowden via Cross Lake Airways. Also charter service is available to both Norway House and Cross Lake by various airlines. For flight information, refer to Table 2.

At the present time road travel is restricted to the Jenpeg access road connection with Provincial Road 373 and subsequently Provincial Road 391. This makes it virtually impossible to travel by automobile from Cross Lake to Provincial Road 391 (without some type of ferry service) and totally impossible to travel by automobile from Norway

TABLE 2

SCHEDULED AIR PASSENGER SERVICE

(Effective December 1, 1972)

From Norway House to:

DESTINATION	AIRCRAFT TYPE	SCHEDULE	FARE
Winnipeg*	Twin Otter Turbo Prop	Daily except Sundays and holidays	$40.00
Thompson*	Twin Otter Turbo Prop	Wednesday only	24.00
The Pas*	Aztec	Monday, Wednesday and Friday only	20.00
Cross Lake**	Twin Otter Turbo Prop	Daily except Sundays and holidays	12.00

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*Trans Air.

**Midwest Airlines.

From Cross Lake to:

DESTINATION	AIRCRAFT TYPE	SCHEDULE	FARE
Winnipeg[+]	Twin Otter Turbo Prop	Daily except Sundays and holidays	$43.00
Wabowden[++]	Float Plane	Daily (summer only)	12.00
Norway House[+]	Twin Otter Turbo Prop	Daily except Sundays and holidays	12.00

[+] Midwest Airlines.

[++] Cross Lake Airways.

House to any other part of Manitoba. Part of the Hydro development may include the construction of a control structure on the East Channel of the Nelson River (see section IIID). A result of this construction could be the connection of Jenpeg with the East Channel control structure by road for the purposes of transporting materials and supplies to the site. If such a road were constructed and circumstances of an economic or social nature warranted accessibility to and from Norway House by road, this road could be extended from the East Channel control structure, (possibly Sea River Falls) to Norway House community (see section III for a more detailed discussion).

With regard to Cross Lake, outside accessibility could be provided by a direct road link with Jenpeg, an air shuttle service between Cross Lake and Jenpeg (primarily to serve a commuter traffic consisting of people working at Jenpeg but living at Cross Lake), or some type of ferry service from Cross Lake to Jenpeg. Section VII discusses the above alternatives in greater detail.

The closest major rail passenger station is at Wabowden on the Hudson Bay Railway. Thus any travel by rail to points outside the Outlet Lakes area requires a means of access to the major rail embarkation point at Wabowden or the flag-down point at Pipun. It is considered unlikely that the Outlet Lakes area will be provided with rail service unless a major mining operation is established (section VD). Construction of a rail branch line would be uneconomical in the light of the present and potential traffic of commodities and people and would not be warranted.

B. Inbound cargo

(1) Norway House: The community of Norway House has four retail outlets and a hotel, however, the two Hudson Bay stores and the Playgreen Inn import the bulk of the general cargo. According to the Northern Stores Department of the Hudson Bay Company, 1,150 tons of general cargo were shipped to Norway House for the fiscal year 1971-72. Of this total, 900 tons was shipped during the summer months from May 31 to October 31. Approximately 30 to 40% of the total general cargo shipped to the Hudson Bay Company at Norway House consists of fresh and frozen food supplies, referred to as perishables in this report. Annually some 1,000,000 gallons of bulk oil are shipped to Norway House[1] forming the largest single source of traffic into the community.

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[1] Marine Transport Limited.

Norway House freight is shipped by boat or barge from Winnipeg or Selkirk in summer months. In periods of low water this freight was transshipped at Warren Landing to shallow draught vessels. During the last few years, however, this transshipment was not required. In winter Norway House obtains the bulk of its supplies by winter truck road from PTH6 along the 15th base line as shown on Map VIII. Air freight has been used mainly during freeze-up and break-up periods: November 1 to January 31 and April 1 to May 31, when neither water transport nor winter roads can be used. Air transport is also used extensively for the shipment of perishable foodstuffs.

The transportation of cargo into Norway House could be altered considerably as a result of the Hydro development. The community is presently isolated from the Provincial road network making the shipment of goods by truck on a year-round basis impossible. An extension of the Jenpeg access road to Norway House, via a possible East Channel control structure, woul change this situation. Cost factors may encourage the integration of the truck link from Norway House to Wabowden with the railway from The Pas and Winnipeg. The barge route could also be improved by use of the 2-Mile Channel to avoid the dangerous shallows in the Warren Landing approach.

The following series of tables and graphs illustrate the cost considerations for each method of transporting inbound cargo. For the purposes of simplicity, the inbound commodities were broken down into three categories: foodstuffs (perishables), general cargo (non-perishables) and fuel oil.

TABLE VIB1

Method 1:

INBOUND CARGO

Origin: Winnipeg Final destination: Norway House

Type of cargo: Food stuffs (perishables)

Mode(s) of transport: Rail and truck (refrigerated)

Linkage(s) and mode(s) used: Winnipeg to Wabowden by rail and Wabowden to Norway House by truck on possible road

Seasonal nature: Summer and winter

Weight (cwt)	Rail		Truck		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
6000	.75	4500	.39	2340	6840
6500	.75	4870	.39	2540	7410
7000	.75	5240	.39	2730	7970
7500	.75	5620	.39	2920	8540
8000	.75	6000	.39	3120	9120
8500	.75	6370	.39	3310	9680
9000	.75	6750	.39	3510	10260

Estimated perishable food stuffs inbound at Norway House is: 6300 during 1971-72.

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VIB2

INBOUND CARGO

Method 2:

Origin: Winnipeg Final destination: Horway House

Type of cargo: Foodstuffs (perishables)

Mode(s) of transport: Truck (refrigerated)

Linkage(s) and mode(s) used: Winnipeg to Norway House by truck via Jenpeg on possible road

Seasonal nature: Summer and winter

Weight (cwt)	Truck	Total Cost $
	Unit Rate $/cwt	
6000	1.29	7740
6500	1.29	8380
7000	1.29	9040
7500	1.29	9670
8000	1.29	10300
8500	1.29	10950
9000	1.29	11600

Note: The rate includes a 10% mark-up for refrigeration-heating service.

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VIB3

INBOUND CARGO

Method 3:

Origin: Winnipeg Final destination: Norway House

Type of cargo: Foodstuffs (perishables)

Mode(s) of transport: Air

Linkage(s) and mode(s) used: Direct flight from Winnipeg to Norway House

Seasonal nature: Summer and winter

Weight (cwt)	Air	Total Cost $
	Unit Rate $/cwt	
6000	11.00	65900
6500	11.00	71400
7000	11.00	77000
7500	11.00	82500
8000	11.00	88000
8500	11.00	93500
9000	11.00	99000

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VIB4

INBOUND CARGO

Method 4:

Origin: Winnipeg Final destination: Norway House

Type of cargo: Foodstuffs (perishables)

Mode(s) of transport: Barge

Linkage(s) and mode(s) used: Direct from Winnipeg (Selkirk) to Norway House by boat or barge

Seasonal nature: Summer only

Weight (cwt)	Barge	Total Cost $
	Unit Rate $/cwt	
6000	3.00	18000
6500	3.00	19500
7000	3.00	21000
7500	3.00	22500
8000	3.00	24000
8500	3.00	25500
9000	3.00	27000

Note: The rate quoted above is from Selkirk to Norway House. The rate from Winnipeg to Norway House is subject to a $0.50 surcharge.

Rate Source: Marine Transport Limited, 1972.

TABLE VIB5

INBOUND CARGO

Method 5:

Origin: Winnipeg Final destination: Norway House

Type of cargo: Foodstuffs (perishables)

Mode(s) of transport: Truck and winter truck (heated)

Linkage(s) and mode(s) used: Winnipeg to PTH6 and base line 15 intersection by truck and from this point to Norway House by winter truck road

Seasonal nature: Winter only

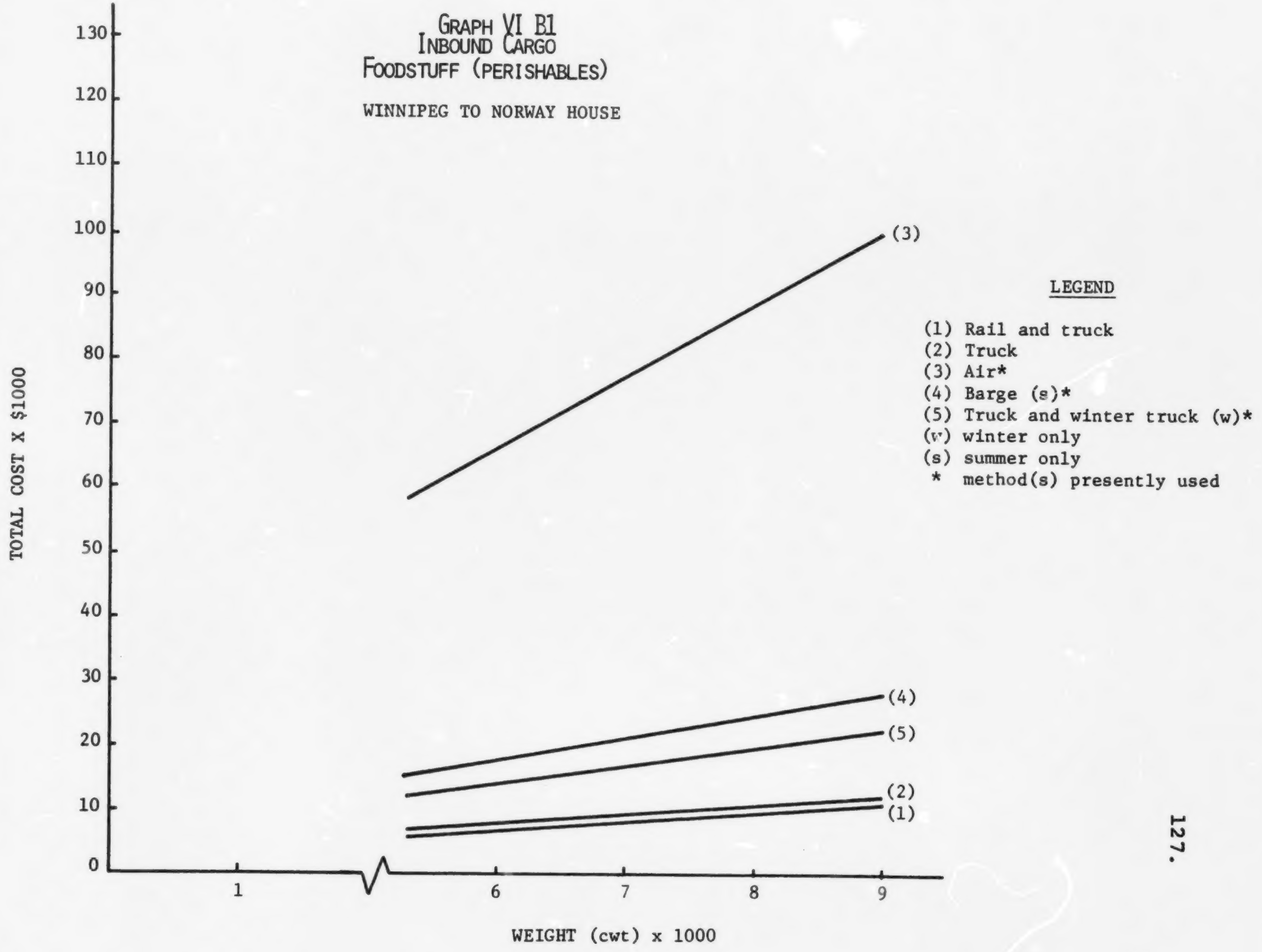
Weight (cwt)	Truck		Winter Truck		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
6000	0.91	5460	1.55	9300	14760
6500	0.91	5810	1.55	10090	15900
7000	0.91	6360	1.55	10850	17210
7500	0.91	6820	1.55	11620	18440
8000	0.91	7270	1.55	12400	19670
8500	0.91	7730	1.55	13190	20920
9000	0.91	8180	1.55	13950	22130

Note: The all-weather truck rate for Winnipeg to PTH6-15th base line includes 10% surcharge for refrigeration-heating. The $1.55 winter truck rate from PTH6-15th base line to Norway House includes $0.50 extra for heating.

Rate Source: Manitoba Department of Industry and Commerce.

GRAPH VI B1
INBOUND CARGO
FOODSTUFF (PERISHABLES)

WINNIPEG TO NORWAY HOUSE



Transportation cost analysis for perishables to Norway House

Method 1:

Winnipeg to Wabowden by rail for transshipment by truck (including possible road from Jenpeg to Norway House) to Norway House.

1. Hydro inputs available:
    - (a) Jenpeg access road
    - (b) Jenpeg control structure - bridgehead
2. Hydro inputs required:
    - (a) East Channel control structure - bridgehead
    - (b) Access road to East Channel control structure from Jenpeg
3. Other inputs required:
    - (a) All-weather road from the East Channel control structure to Norway House
4. General shipping cost for potential traffic (annual):

    Amount (1971-72): 6300 cwt Cost: $7,000
5. Rank of method:

    First out of five methods
6. Hydro development impact on method:

    Hydro development would have a major beneficial impact on this means of importing perishables since it provides the bulk of the infrastructure in the Outlet Lakes area required for this method.

Method 2:

Winnipeg to Norway House (including a possible road from Jenpeg to Norway House) by truck.

1. Hydro inputs available:
   (a) Jenpeg access road
   (b) Jenpeg control structure - bridgehead
2. Hydro inputs required:
   (a) East Channel control structure - bridgehead
   (b) Access road to East Channel control structure from Jenpeg
3. Other inputs required:
   (a) All-weather road from the East Channel control structure to Norway House
4. General shipping cost for potential traffic (annual):
   Amount (1971-72): 6300 cwt Cost: $8,000
5. Rank of method:
   Second out of five methods
6. Hydro development impact on method:
   Similar to method one.

Method 3:

By air from Winnipeg to Norway House.

1. Hydro inputs available: Nil
2. Hydro inputs required: Nil

3. Other inputs required: Nil

4. General shipping cost for potential traffic (annual):

   Amount (1971-72): 6300 cwt Cost: $70,000

5. Rank of method:

   Fifth out of five methods

6. Hydro development impact on method:

   Hydro development will not affect this method.

Method 4:

Winnipeg or Selkirk to Norway House by boat or barge.

1. Hydro inputs available:

   (a) 2-Mile Channel

2. Hydro inputs required: Nil

3. Other inputs required: Nil

4. General shipping cost for potential traffic (annual):

   Amount (1971-72): 6300 cwt Cost: $19,000

5. Rank of method:

   Fourth out of five methods

6. Hydro development impact on method:

   Hydro development would have a minor beneficial impact on this method of importing perishables due to the improvement of the navigation route (2-Mile Channel).

Method 5:

Winnipeg to intersection of PTH6 and 15th base line by all-weather road (truck) and from this point to Norway House by winter road (truck).

1. Hydro inputs available: Nil
2. Hydro inputs required: Nil
3. Other inputs required: Nil
4. General shipping cost for potential traffic (annual):

   Amount (1971-72): 6300 cwt Cost: $15,000
5. Rank of method:

   Third out of five methods
6. Hydro development impact on method:

   The Hydro development will have no quantifiable affect on this method.

TABLE VIB6

INBOUND CARGO

Method 1:

Origin: Winnipeg Final destination: Norway House

Type of cargo: General merchandise (non-perishables)

Mode(s) of transport: Truck

Linkage(s) and mode(s) used: Winnipeg to 15th base line by truck via PTH6 and by winter truck road along 15th base line to Norway House

Seasonal nature: Winter only

Weight (cwt)	Truck PTH6		Truck Winter Road		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
4000	.83	3420	1.05	4200	7620
8000	.83	6640	1.05	8400	15040
12000	.83	9960	1.05	12600	22560
16000	.83	13280	1.05	16800	30080
20000	.83	16600	1.05	21000	37600
24000	.83	19920	1.05	25600	45520
28000	.83	23240	1.05	29400	52640
32000	.83	26660	1.05	33600	60260

Estimated general cargo inbound to Norway House is 5000 cwt in Winter 1971.

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VIB7

INBOUND CARGO

Method 2:

Origin: Winnipeg Final destination: Norway House

Type of cargo: General merchandise (non-perishables)

Mode(s) of transport: Truck

Linkage(s) and mode(s) used: Winnipeg to Norway House by truck (includes possible road link from Jenpeg to Norway House)

Seasonal nature: Winter and summer

Weight (cwt)	Truck	Total Cost $
	Unit Rate $/cwt	
4000	1.17	4680
8000	1.17	9360
12000	1.17	14040
16000	1.17	18720
20000	1.17	23400
24000	1.17	28080
28000	1.17	32760
32000	1.17	37440

Estimated general cargo inbound to Norway House is 23000 cwt in 1971.

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VIB8

INBOUND CARGO

Method 3:

Origin: Winnipeg Final destination: Norway House

Type of cargo: General merchandise (non-perishables)

Mode(s) of transport: Rail and truck

Linkage(s) and mode(s) used: Winnipeg to Wabowden by rail and Wabowden to Norway House by truck (includes possible road link from Jenpeg to Norway House)

Seasonal nature: Summer and winter

Weight (cwt)	Rail		Truck		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
4000	.75	3000	.35	10500	13500
8000	.75	6000	.35	21000	27000
12000	.75	9000	.35	31500	40500
16000	.75	12000	.35	42000	54000
20000	.75	15000	.35	52500	67500
24000	.75	18000	.35	63000	81000
28000	.75	21000	.35	73500	94500
32000	.75	24000	.35	84000	108000

Estimated general cargo inbound to Norway House is 23000 cwt in 1971.

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VIB9

INBOUND CARGO

Method 4:

Origin: Winnipeg Final destination: Norway House

Type of cargo: General merchandise (non-perishables)

Mode(s) of transport: Barge

Linkage(s) and mode(s) used: Winnipeg (Selkirk) to Norway House by barge via Lake Winnipeg

Seasonal nature: Summer only

Weight (cwt)	Barge	Total Cost $
	Unit Rate $/cwt	
4000	1.85	7400
8000	1.85	14800
12000	1.85	22200
16000	1.85	29600
20000	1.85	37000
24000	1.85	44400
28000	1.85	51800
32000	1.85	59200

Estimated general cargo inbound to Norway House is 18000 cwt in Summer 1971.

Rate Source: Marine Transport Limited.

TABLE VIB10

INBOUND CARGO

Method 5:

Origin: Winnipeg Final destination: Norway House

Type of cargo: General merchandise (non-perishable)

Mode(s) of transport: Air

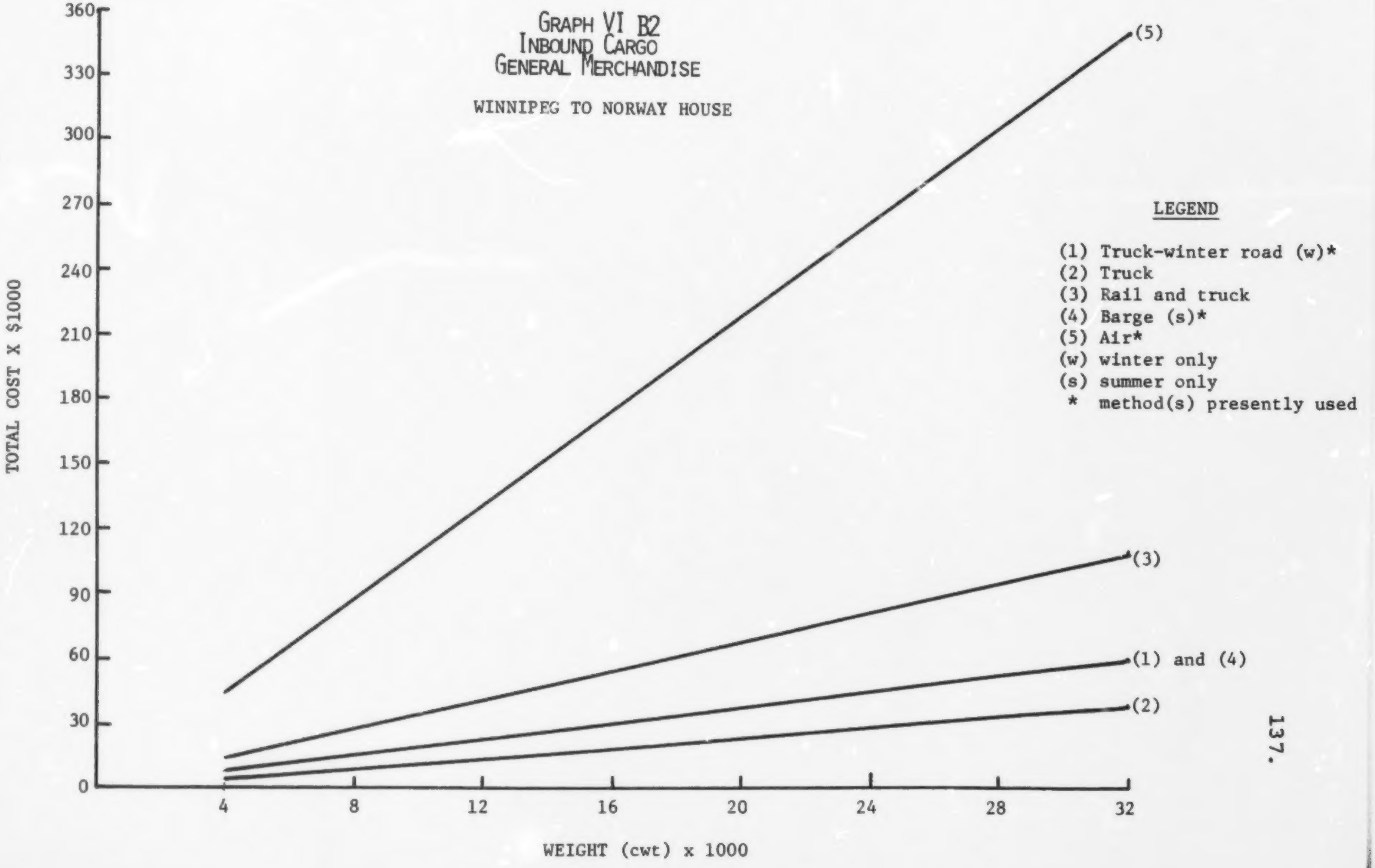
Linkage(s) and mode(s) used: Winnipeg to Norway House by air direct.

Seasonal nature: Winter and summer

Weight (cwt)	Air	Total Cost $
	Unit Rate $/cwt	
4000	11.00	44000
8000	11.00	88000
12000	11.00	132000
16000	11.00	176000
20000	11.00	220000
24000	11,00	264000
28000	11.00	308000
32000	11.00	352000

Estimated general cargo inbound to Norway House is 23000 cwt in 1971.

Rate Source: Manitoba Department of Industry and Commerce.



GRAPH VI B2
INBOUND CARGO
GENERAL MERCHANDISE

WINNIPEG TO NORWAY HOUSE

Transportation cost analysis for general cargo to Norway House

Method 1:

Movement of general cargo (non-perishables) by truck from Winnipeg to the intersection of PTH6 and the 15th base line and then by winter truck following the 15th base line to Norway House (winter only).

1. Hydro inputs available: Nil
2. Hydro inputs required: Nil
3. Other inputs required: Nil
4. General shipping cost for potential traffic (annual):

   Amount (Hudson Bay Co. 1971): 23000 cwt Cost: $43,000
5. Rank of method:

   Second out of five methods (tied).
6. Hydro development impact on method:

   Hydro development does not affect this method.

Method 2:

Winnipeg to Norway House via PTH6, the Jenpeg access road and its possible extension to Norway House.

1. Hydro inputs available:
   (a) Jenpeg access road
   (b) Jenpeg control structure - bridgehead
2. Hydro inputs required:
   (a) East Channel control structure access road

(b) East Channel control structure - bridgehead

3. Other inputs required:

(a) East Channel control structure road connection to Norway House

4. General shipping cost for potential traffic (annual):

Amount (Hudson Bay Co. 1972): 23000 cwt Cost: $27,000

5. Rank of method:

First out of five methods

6. Hydro development impact on method:

Hydro development has a major beneficial impact on the potential utilization of this method, having provided the greatest portion of the infrastructure in the Outlet Lakes area, necessary for further extension.

Method 3:

Winnipeg to Wabowden by rail where cargo is transshipped to truck for furtherance to Norway House via the Jenpeg access road and its possible extension.

1. Hydro inputs available:

(1) Jenpeg access road

(2) Jenpeg control structure - bridgehead

2. Hydro inputs required:

(a) East Channel control structure access road from Jenpeg

(b) East Channel control structure - bridgehead

3. Other inputs required:

   (a) East Channel control structure connection to Norway House

4. General shipping cost for potential traffic (annual):

   Amount (Hudson Bay Co. 1972): 23000 cwt   Cost: $73,000

5. Rank of method:

   Fourth out of five methods

6. Hydro development impact on method:

   Same as method two.

Method 4:

Winnipeg or Selkirk to Norway House by barge via the 2-Mile Channel (summer only).

1. Hydro inputs available:

   (a) 2-Mile Channel

2. Hydro inputs required: Nil

3. Other inputs required: Nil

4. General shipping cost for potential traffic (annual):

   Amount (Hudson Bay Co. 1972): 23000 cwt   Cost: $40,000

5. Rank of method:

   Second out of five methods (tied).

6. Hydro development impact on method:

   Hydro development has some beneficial impact on the potential use of this route having provided the 2-Mile Channel thus bypassing the more hazardous Warren Landing approach.

Method 5:

Winnipeg to Norway House direct by aircraft.

1. Hydro inputs available: Nil
2. Hydro inputs required: Nil
3. Other inputs required: Nil
4. General shipping cost for potential traffic (annual):

   Amount (Hudson Bay Co. 1972): 23000 cwt Cost: $255,000
5. Rank of method:

   Fifth out of five methods.
6. Hydro development impact on method:

   Hydro development does not affect this method.

TABLE VIB11

INBOUND CARGO

Method 1:

Origin: Regina Final destination: Norway House

Type of cargo: Fuel oil

Mode(s) of transport: Rail and truck

Linkage(s) and mode(s) used: Regina to Wabowden by rail and Wabowden to Norway House by truck on possible road connection from Jenpeg.

Seasonal nature: Summer and winter

Weight (cwt)	Rail		Truck		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
60000	1.02	61200	.35	21000	82200
65000	1.02	66300	.35	22750	89050
70000	1.02	71400	.35	24500	95900
75000	1.02	76500	.35	26350	102750
80000	1.02	81600	.35	28000	109600
85000	1.02	86700	.35	29750	116450
90000	1.02	91800	.35	31500	123300
95000	1.02	96900	.35	32250	129150
100000	1.02	102000	.35	35000	137000
105000	1.02	107100	.35	36750	143850
110000	1.02	112200	.35	38500	150700

Note: In the summer of 1972 Marine Transport shipped approximately 8,000,000 lb. of bulk fuel into Norway House (1 gallon = 8 lb.)

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VIB12

INBOUND CARGO

Method 2:

Origin: Winnipeg   Final destination: Norway House

Type of cargo: Fuel oil

Mode(s) of transport: Truck

Linkage(s) and mode(s) used: Winnipeg to Norway House by truck via Wabowden, Jenpeg access road and possible Norway House extension

Seasonal nature: Summer and winter

Weight (cwt)	Truck	Total Cost $
	Unit Rate $/cwt	
60000	1.17	70200
65000	1.17	76050
70000	1.17	81900
75000	1.17	87750
80000	1.17	93600
85000	1.17	99450
90000	1.17	105300
95000	1.17	111150
100000	1.17	117000
105000	1.17	122850
110000	1.17	128700

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VIB13

INBOUND CARGO

Method 3:

Origin: Winnipeg Final destination: Norway House

Type of cargo: Fuel oil

Mode(s) of transport: Barge

Linkage(s) and mode(s) used: Direct from Winnipeg (Selkirk) to Norway House by barge

Seasonal nature: Summer only

Weight (cwt)	Barge	Total Cost $
	Unit Rate $/cwt	
60000	1.50	90000
65000	1.50	97500
70000	1.50	105000
75000	1.50	112500
80000	1.50	120000
85000	1.50	127500
90000	1.50	135000
95000	1.50	142500
100000	1.50	150000
105000	1.50	157500
110000	1.50	165000

Rate Source: Marine Transport Limited, 1972.

TABLE VIB14

INBOUND CARGO

Method 4:

Origin: Winnipeg Final destination: Norway House

Type of cargo: Fuel oil

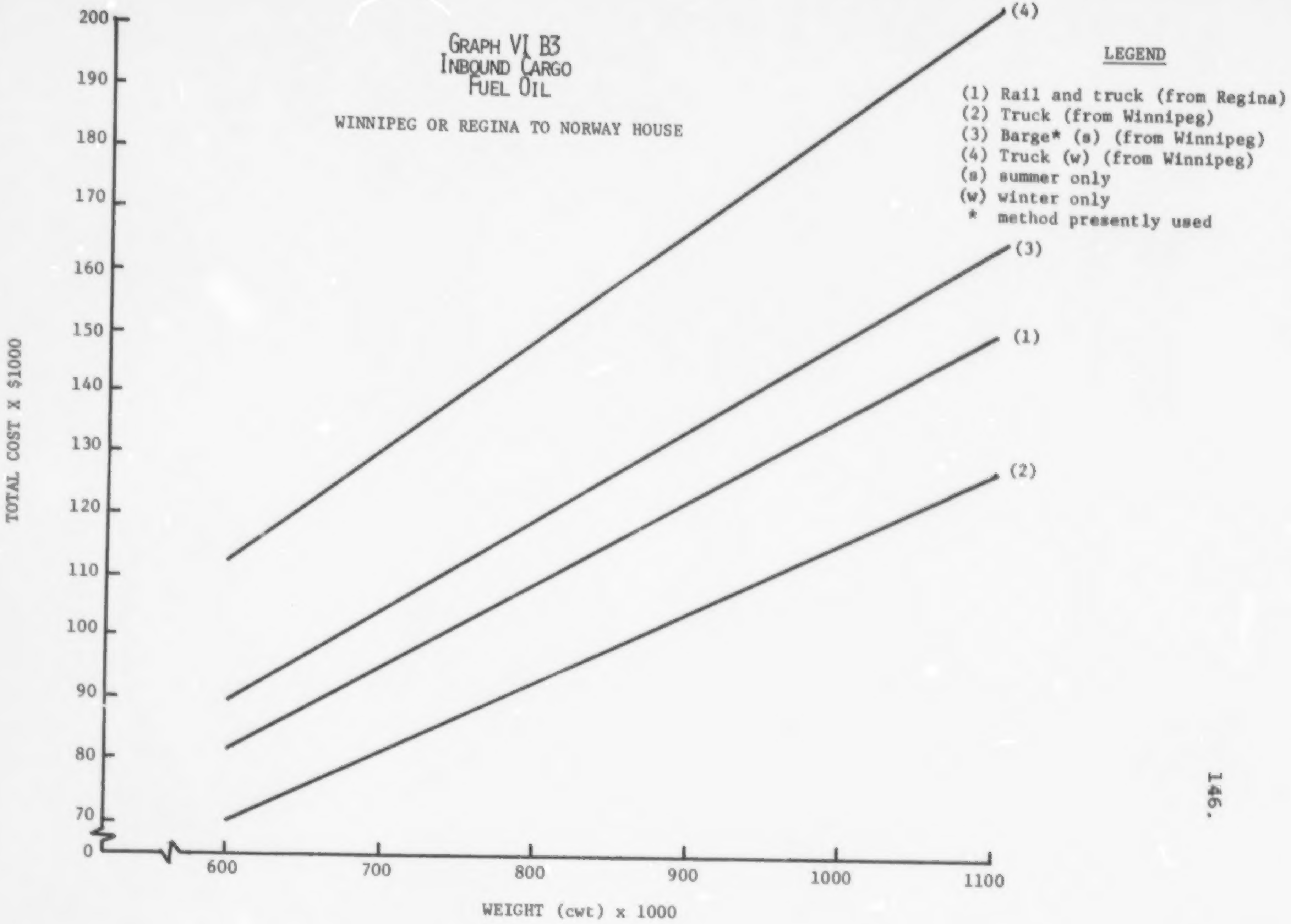
Mode(s) of transport: Truck (winter)

Linkage(s) and mode(s) used: Winnipeg via PTH6 to the 15th base line by truck and from there to Norway House by winter truck road

Seasonal nature: Winter only

Weight (cwt)	Truck		Winter Truck		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
60000	.83	49800	1.05	63000	112800
65000	.83	53950	1.05	68250	122200
70000	.83	58100	1.05	73500	131600
75000	.83	62250	1.05	78750	141000
80000	.83	66400	1.05	84000	150400
85000	.83	70550	1.05	89250	159800
90000	.83	74700	1.05	94500	169200
95000	.83	78850	1.05	99750	178600
100000	.83	83000	1.05	105000	183000
105000	.83	87150	1.05	110250	197400
110000	.83	91300	1.05	115500	206800

Rate Source: Manitoba Department of Industry and Commerce.



GRAPH VI B3
INBOUND CARGO
FUEL OIL

WINNIPEG OR REGINA TO NORWAY HOUSE

Transportation cost analysis for fuel oil to Norway House

Method 1:

Movement of fuel oil from Regina to Wabowden by rail, and transshipment to truck for furtherance to Norway House via the Jenpeg access road and the Norway House extension.

1. Hydro inputs available:
   (a) Jenpeg access road
   (b) Jenpeg control structure - bridgehead
2. Hydro inputs required:
   (a) Jenpeg access road extension to the East Channel control structure
   (b) East Channel control structure - bridgehead
3. Other inputs required:
   (a) East Channel control structure road connection to Norway House
4. General shipping cost for potential traffic (annual):
   Amount (1972): 80000 cwt Cost: $109,600
5. Rank of method:
   Second out of four methods
6. Hydro development impact on method:
   Hydro development has a major beneficial impact on the potential utilization of this method, having provided the greatest portion of the infrastructure in the Outlet Lakes area necessary for this removal.

Method 2:

Winnipeg to Norway House by truck using PTH6, the Jenpeg access road and its possible extension to Norway House.

1. Hydro inputs available:
   - (a) Jenpeg access road
   - (b) Jenpeg control structure - bridgeheas
2. Hydro inputs required:
   - (a) Jenpeg access road extension to the East Channel control structure
   - (b) East Channel control structure - bridgehead
3. Other inputs required:
   - (a) East Channel control structure road connection to Norway House
4. General shipping cost for potential traffic (annual):

   Amount (1972): 80000 cwt   Cost: $93,600
5. Rank of method:

   First out of four methods.
6. Hydro development impact on method:

   Same as method one.

Method 3:

Winnipeg to Norway House by barge via the 2-Mile Channel (summer only).

1. Hydro inputs available:
   - (a) 2-Mile Channel

2. Hydro inputs required: Nil

3. Other inputs required: Nil

4. General shipping cost potential traffic (annual):

   Amount (1972): 80000 cwt Cost: $120,000

5. Rank of method:

   Third out of four methods

6. Hydro development impact on method:

   Hydro development has some beneficial impact on the potential utilization of this method, since it provides the 2-Mile Channel for access from Playgreen Lake to Lake Winnipeg bypassing the hazardous Warren Landing approach.

Method 4:

Winnipeg to the intersection of PTH6 and the 15th base line by truck and then by winter truck road along the 15th base line to Norway House.

1. Hydro inputs available: Nil

2. Hydro inputs required: Nil

3. Other inputs required: Nil

4. General shipping cost for potential traffic (annual):

   Amount (1972): 80000 cwt Cost: $150,400

5. Rank of method:

   Fourth out of four methods

6. Hydro development impact on method:

Hydro development does not affect this method appreciably.

(2) Cross Lake: The community of Cross Lake has only one retail outlet, the Hudson 'Bay Company store. Figures obtained from the Northern Stores Department of the Hudson Bay Company indicated a total annual shipment of 1,150 tons of cargo other than fuel oil for 1971-72, 350 tons of which was shipped in during the summer months (May 31 to October 31) and 800 tons during the winter. Of this total (1,150) approximately 250 tons was in the form of fresh and frozen food supplies.

M.M. Dillon, in their Cross Lake Transportation Study, estimated a total annual shipment to Cross Lake of approximately 2,700 tons of cargo exclusive of fuel oil. Of this figure, about 60 percent or 1,650 tons was shipped by winter road to the community.

No exact figure was obtainable for the amount of fuel oil imported by Cross Lake community. However, an estimate of 750,000 gallons per year was deemed reasonable by the Manitoba Department of Industry and Commerce.

Summer freight to Cross Lake is delivered by boat and barge from Winnipeg through Warren Landing to the south end of Whiskey Jack Portage. At this point greight is trucked across the 5-Mile Portage and then transshipped to a barge for furtherance to Cross Lake. Both Marine Transport Limited and Northland Freight and Forwarding Limited, provide service as farr as Whiskey Jack and Fred Sinclair of Cross Lake provides service beyond that point to the community. Winter freight has in the past gone by truck or rail to Wabowden, then by tractor train to Cross Lake. Air freight to Cross Lake is provided by either direct service from Norway House and Winnipeg or in summer only, by sea plane from Wabowden where freight is transshipped from truck or rail.

The construction of the Jenpeg access road has put Cross Lake within approximately 10 miles of an all-weather road connection to the outside world. The impact of this road (a direct result of Hydro development) on the inbound movement of cargo to Cross Lake has been dramatic. The winter road formerly from Wabowden now extends from Jenpeg, a reduction of some 35 miles in length. There is speculation that some of the freight now being barged in summer via Whiskey Jack will be diverted to being trucked via the Jenpeg access road as far as the Minago River crossing where it may be transshipped to a boat or barge for shipment to Cross Lake. During periods of the year when boat and winter truck operations are impossible a shuttle service from the Jenpeg airstrip to Cross Lake could be used. All these ramifications would of course be altered should the Jenpeg access road be extended to Cross Lake. All-weather road connection would eliminate the disadvantages of transshipment which is necessary in the other methods. Improvements to the navigation route as a result of the diversion channels and the Jenpeg forebay will make it possible for vessels to navigate as far as the Jenpeg structure. In the future, certain types of bulk cargo may be shipped to Cross Lake from Winnipeg by barge either by means of a short transshipment at Jenpeg or direct by way of a possible lock structure in the Jenpeg dam, thus bypassing the Whiskey Jack Portage.

The following series of tables and graphs illustrate the cost considerations of each method of transporting inbound cargo. As was the case for Norway House, the cargo types are divided into: foodstuffs (perishables), general cargo (non-perishables) and fuel oil.

TABLE VIB15

INBOUND CARGO

Method 1:

Origin: Winnipeg Final destination: Cross Lake

Type of cargo: Foodstuffs (perishables)

Mode(s) of transport: Rail and truck (refrigerated)

Linkage(s) and mode(s) used: Winnipeg to Wabowden by rail and Wabowden to Cross Lake by possible road

Seasonal nature: Summer and winter

Weight (cwt)	Rail		Truck		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
4000	.75	3000	.32	1280	4280
4500	.75	3380	.32	1440	4820
5000	.75	3750	.32	1600	5350
5500	.75	4120	.32	1760	5880
6000	.75	4500	.32	1920	6420
6500	.75	4870	.32	2080	6950
7000	.75	5240	.32	2240	7480
7500	.75	5620	.32	2400	8020
8000	.75	6000	.32	2560	8560

Estimated perishable foodstuffs inbound at Cross Lake is 5000 cwt during 1971-72.

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VIB16

INBOUND CARGO

Method 2:

Origin: Winnipeg Final destination: Cross Lake

Type of cargo: Foodstuffs (perishables)

Mode(s) of transport: Truck (refrigerated)

Linkage(s) and mode(s) used: Winnipeg to Cross Lake by truck via Jenpeg and possible road extension

Seasonal nature: Summer and winter

Weight (cwt)	Truck	Total Cost $
	Unit Rate $/cwt	
4000	1.20	4800
4500	1.20	5400
5000	1.20	6000
5500	1.20	6600
6000	1.20	7200
6500	1.20	7800
7000	1.20	8400
7500	1.20	9000
8000	1.20	9600

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VIB17

INBOUND CARGO

Method 3:

Origin: Winnipeg Final destination: Cross Lake

Type of cargo: Foodstuffs (perishables)

Mode(s) of transport: Air

Linkage(s) and mode(s) used: Direct flight from Winnipeg to Cross Lake

Seasonal nature: Summer and winter

Weight (cwt)	Air	Total Cost $
	Unit Rate $/cwt	
4000	12.00	48000
4500	12.00	54000
5000	12.00	60000
5500	12.00	66000
6000	12.00	72000
6500	12.00	78000
7000	12.00	84000
7500	12.00	90000
8000	12.00	96000

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VIB18

INBOUND CARGO

Method 4:

Origin: Winnipeg   Final destination: Cross Lake

Type of cargo: Foodstuffs (perishables)

Mode(s) of transport: Barge

Linkage(s) and mode(s) used: Direct from Winnipeg (Selkirk) to Cross Lake via possible Jenpeg lock

Seasonal nature: Summer only

Weight (cwt)	Barge	Total Cost $
	Unit Rate $/cwt	
4000	3.60	14400
4500	3.60	16200
5000	3.60	18000
5500	3.60	19800
6000	3.60	21600
6500	3.60	23400
7000	3.60	25200
7500	3.60	27000
8000	3.60	28800

Note: Adjusted from rate now charged for shipment to Whiskey Jack $3.50 + 0.10 = $3.60

Rate Source: Marine Transport Limited, 1972.

TABLE VIB19

INBOUND CARGO

Method 5:

Origin: Winnipeg Final destination: Cross Lake

Type of cargo: Foodstuffs (perishables)

Mode(s) of transport: Rail and air

Linkage(s) and mode(s) used: Winnipeg to Wabowden by rail and Wabowden to Cross Lake by sea plane

Seasonal nature: Summer

Weight (cwt)	Rail		Air		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
4000	0.75	3000	3.00	12000	15000
4500	0.75	3380	3.00	13500	16880
5000	0.75	3750	3.00	15000	18750
5500	0.75	4120	3.00	16500	20620
6000	0.75	4500	3.00	18000	22500
6500	0.75	4870	3.00	19500	24370
7000	0.75	5240	3.00	21000	26240
7500	0.75	5620	3.00	22500	28120
8000	0.75	6000	3.00	24000	30000

Rate Sources: M.M. Dillon Report, 1971 and Manitoba Department of Industry and Commerce.

TABLE VIB20

INBOUND CARGO

Method 6:

Origin: Winnipeg Final destination: Cross Lake

Type of cargo: Foodstuffs (perishables)

Mode(s) of transport: Barge

Linkage(s) and mode(s) used: Winnipeg (Selkirk) to Whiskey Jack by barge, Whiskey Jack to Cross Lake by small barge

Seasonal nature: Summer

Weight (cwt)	Barge		Small Barge		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate* $/cwt	Subtotal $	
4000	3.50	14000	1.50	6000	20000
4500	3.50	15750	1.50	6750	22500
5000	3.50	17500	1.50	7500	25000
5500	3.50	19250	1.50	8240	27490
6000	3.50	21000	1.50	9000	30000
6500	3.50	22750	1.50	9740	32490
7000	3.50	24500	1.50	10500	35000
7500	3.50	26200	1.50	11250	37450
8000	3.50	28000	1.50	12000	40000

*Note: Rate includes short truck haul over Whiskey Jack Portage.

Rate Source: Marine Transportation Limited and M.M. Dillon Report.

TABLE VI B21

INBOUND CARGO

Method 7:

Origin: Winnipeg Final destination: Cross Lake

Type of cargo: Foodstuffs (perishables)

Mode(s) of transport: Truck and boat

Linkage(s) and mode(s) used: Winnipeg to Minago River crossing west of Jenpeg by truck and Minago River to Cross Lake by barge

Seasonal nature: Summer

Weight (cwt)	Truck		Barge		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
4000	1.15	4600	1.10	4400	9000
4500	1.15	5170	1.10	4950	10120
5000	1.15	5740	1.10	5500	11240
5500	1.15	6310	1.10	6050	12360
6000	1.15	6900	1.10	6600	13500
6500	1.15	7460	1.10	7150	14610
7000	1.15	8050	1.10	7700	15750
7500	1.15	8620	1.10	8250	16870
8000	1.15	9190	1.10	8800	17990

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VIB22

INBOUND CARGO

Method 8:

Origin: Winnipeg Final destination: Cross Lake

Type of cargo: Foodstuffs (perishables)

Mode(s) of transport: Truck (refrigerated-heated)

Linkage(s) and mode(s) used: Winnipég to Jenpeg by all-weather road (truck) and to Cross Lake by winter road (truck)

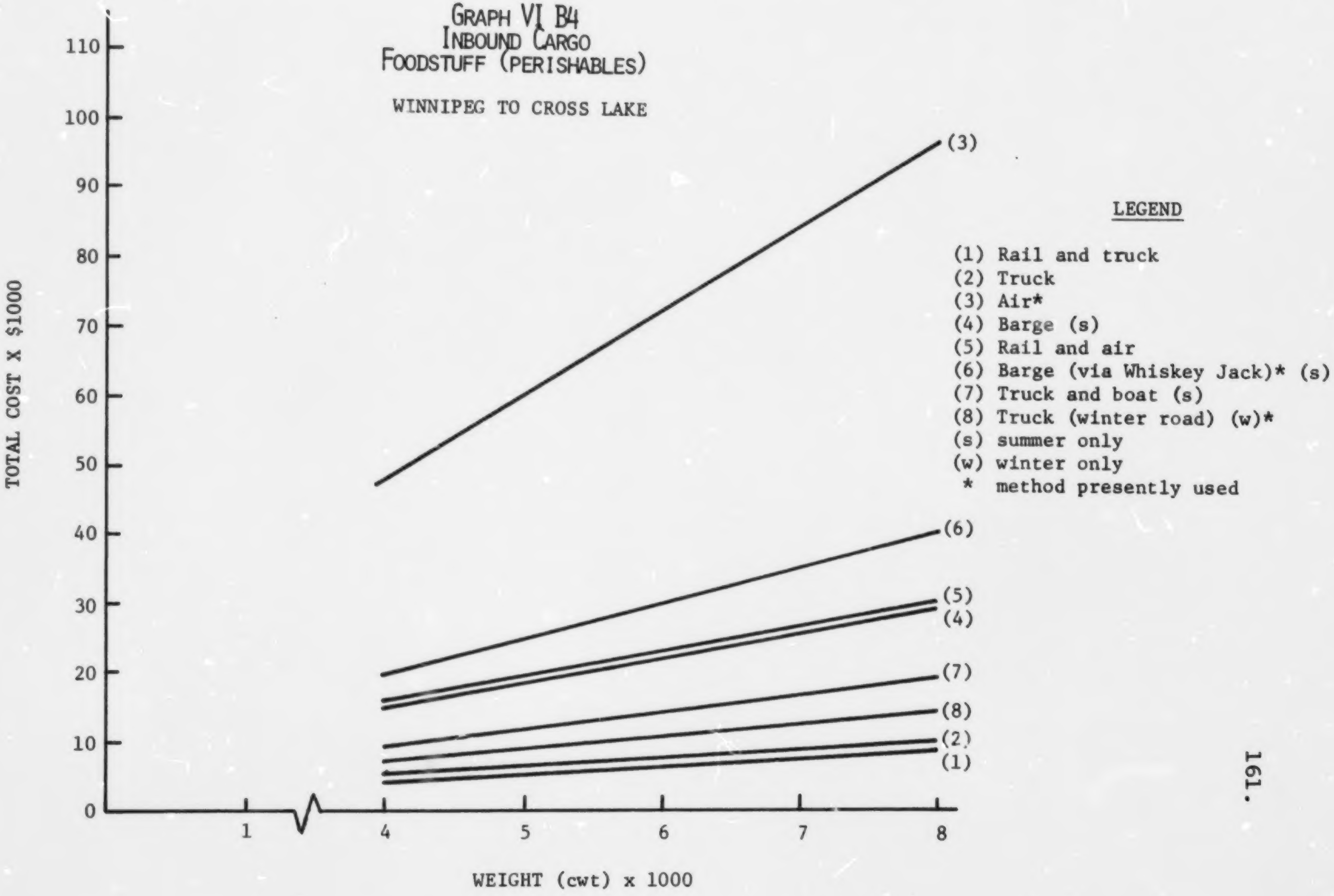
Seasonal nature: Winter only

Weight (cwt)	Truck to Jenpeg		Truck to Cross Lake		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
4000	1.16	4640	.60	2400	7040
4500	1.16	5220	.60	2700	7920
5000	1.16	5800	.60	3000	8800
5500	1.16	6380	.60	3300	9480
6000	1.15	6960	.60	3600	10560
6500	1.16	7540	.60	3900	11440
7000	1.16	8120	.60	4200	12320
7500	1.16	8700	.60	4500	13200
8000	1.16	9280	.60	4800	14080

Rate Source: Manitoba Department of Industry and Commerce.

GRAPH VI B4
INBOUND CARGO
FOODSTUFF (PERISHABLES)

WINNIPEG TO CROSS LAKE



Transportation cost analysis for perishables to Cross Lake

Method 1:

Winnipeg to Wabowden by rail for transshipment to Cross Lake (including possible Cross Lake-Jenpeg road) by truck.

1. Hydro inputs available:
   (a) Jenpeg access road
   (b) Jenpeg control structure - bridgehead
2. Hydro inputs required: Nil
3. Other inputs required:
   (a) Jenpeg access road extension to Cross Lake
4. General shipping cost for potential traffic (annual):
   Amount (1971-72): 5000 cwt Cost: $5,350
5. Rank of method:
   First out of eight methods.
6. Hydro development impact on method:
   Hydro development has a major beneficial impact on the potential utilization of this method, having provided the greatest portion of the infrastructure in the Outlet Lakes area necessary for importation.

Method 2:

Winnipeg to Cross Lake by truck (including possible Jenpeg-Cross Lake road).

1. Hydro inputs available:

   (a) Jenpeg access road

   (b) Jenpeg control structure - bridgehead

2. Hydro inputs required: Nil

3. Other inputs required:

   (a) Jenpeg access road extension to Cross Lake

4. General shipping cost for potential traffic (annual):

   Amount (1971-72): 5000 cwt   Cost: $6,000

5. Rank of method:

   Second out of eight methods

6. Hydro development impact on method:

   Similar to method one.

Method 3:

Winnipeg to Cross Lake by aircraft.

1. Hydro inputs available: Nil

2. Hydro inputs required: Nil

3. Other inputs required: Nil

4. General shipping cost for potential traffic (annual):

   Amount (1971-72): 5000 cwt   Cost: $60,000

5. Rank of method:

   Eighth out of eight methods

6. Hydro development impact on method:

   Hydro development has no impact on this method.

Method 4:

Winnipeg by boat or barge via 2-Mile Channel, 8-Mile Channel, Ominawin Bypass and possible lock at Jenpeg to Cross Lake (summer only).

1. Hydro inputs available:
   - (a) Jenpeg control structure
   - (b) Ominawin Bypass
   - (c) 8-Mile Channel
   - (d) 2-Mile Channel
2. Hydro inputs required:
   - (a) Provision for a lock in the Jenpeg structure
3. Other inputs required:
   - (a) Lock in the Jenpeg control structure
4. General shipping cost for potential traffic (annual):

   Amount (1971-72): 5000 cwt Cost: $18,000
5. Rank of method:

   Fifth of eight methods
6. Hydro development impact on method:

   Hydro development has a major beneficial impact on this method, providing the necessary navigational improvements (Ominawin Bypass, 8-Mile and 2-Mile Channels) necessary for utilization of this importation procedure.

Method 5:

Winnipeg to Wabowden by rail for transshipment to sea plane and furtherance to Cross Lake (summer only).

1. Hydro inputs available: Nil
2. Hydro inputs required: Nil
3. Other inputs required: Nil
4. General shipping cost for potential traffic (annual):

   Amount (1971-72): 5000 cwt Cost: $18,750
5. Rank of method:

   Sixth out of eight methods
6. Hydro development impact on method:

   Hydro development has no affect on this method.

Method 6:

Winnipeg to Whiskey Jack Portage by boat or barge for furtherance via truck and small barge to Cross Lake.

1. Hydro inputs available:
   (a) 2-Mile Channel
2. Hydro inputs required: Nil
3. Other inputs required:
   (a) Raising Whiskey Jack Portage wharves to an elevation above maximum regulated level
4. General shipping cost for potential traffic (annual):

   Amount (1971-72): 5000 cwt Cost: $25,000

5. Rank of method:

   Seventh out of eight methods.

6. Hydro development impact on method:

   Provision of the 2-Mile Channel as an alternative to the hazardous Warren Landing approach is a beneficial impact. This is offset by the necessity of raising the Whiskey Jack Portage wharves above maximum regulated flood stage.

Method 7:

Winnipeg to the Minago River crossing of the Jenpeg access road by truck for transshipment to small barge and furtherance to Cross Lake.

1. Hydro inputs available:

   (a) Jenpeg access road

2. Hydro inputs required: Nil

3. Other inputs required:

   (a) Wharf at the Minago River crossing

4. General shipping cost for potential traffic (annual):

   Amount (1971-72): 5000 cwt Cost: $11,240

5. Rank of method:

   Fourth out of eight methods

6. Hydro development impact on method:

   Due to the accessibility provided by the Jenpeg access road the impact on this method of importation is beneficial.

Method 8:

Winnipeg to Jenpeg via all-weather (truck) road and Jenpeg to Cross Lake via winter (truck) road.

1. Hydro inputs available:
   (a) Jenpeg access road
2. Hydro inputs required: Nil
3. Other inputs required: Nil
4. General shipping cost for potential traffic (annual):
   Amount (1971-72): 5000 cwt   Cost: $8800
5. Rank of method:
   Third out of eight methods
6. Hydro development impact on method:
   Similar to method seven.

TABLE VIB23

INBOUND CARGO

Method 1:

Origin: Winnipeg   Final destination: Cross Lake

Type of cargo: General merchandise (non-perishables)

Mode(s) of transport: Truck

Linkage(s) and mode(s) used: Winnipeg to Jenpeg by truck via all-weather road and Jenpeg to Cross Lake by truck via winter truck road

Seasonal nature: Winter only

Weight (cwt)	Truck (All-weather Road)		Truck (Winter Road)		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
4000	1.05	4200	.35	10500	14700
8000	1.05	8400	.35	21000	29400
12000	1.05	12600	.35	31500	44100
16000	1.05	16800	.35	42000	58800
20000	1.05	21000	.35	52500	73500
24000	1.05	25200	.35	63000	88200
28000	1.05	29400	.35	73500	102900
32000	1.05	33600	.35	84000	117600

Estimated general cargo inbound to Cross Lake is 16000 cwt in Winter 1971 (Hudson Bay Co.).

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VIB24

INBOUND CARGO

Method 2:

Origin: Winnipeg Final destination: Cross Lake

Type of cargo: General merchandise (non-perishable)

Mode(s) of transport: Truck

Linkage(s) and mode(s) used: Winnipeg to Cross Lake by truck (using possible Jenpeg-Cross Lake road connection)

Seasonal nature: Winter and summer

Weight (cwt)	Truck	Total Cost $
	Unit Rate $/cwt	
4000	1.09	4360
8000	1.09	8720
12000	1.09	13080
16000	1.09	17440
20000	1.09	21800
24000	1.09	26160
28000	1.09	30520
32000	1.09	34880

Estimated general cargo inbound to Cross Lake is 23000 cwt in 1971 (Hudson Bay Co.).

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VIB25

INBOUND CARGO

Method 3:

Origin: Winnipeg Final destination: Cross Lake

Type of cargo: General merchandise (non-perishables)

Mode(s) of transport: Rail and truck

Linkage(s) and mode(s) used: Winnipeg to Wabowden by rail and Wabowden to Cross Lake by truck (using possible Jenpeg-Cross Lake road connection)

Seasonal nature: Summer and winter

Weight (cwt)	Rail		Truck		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
4000	.75	3000	.29	1160	4160
8000	.75	6000	.29	2320	8320
12000	.75	9000	.29	3480	12480
16000	.75	12000	.29	4640	16640
20000	.75	15000	.29	5800	20800
24000	.75	18000	.29	6960	24960
28000	.75	21000	.29	8120	29120
32000	.75	24000	.29	9280	33280

Estimated general cargo inbound to Cross Lake is 23000 cwt in 1971 (Hudson Bay Co.).

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VIB26

INBOUND CARGO

Method 4:

Origin: Winnipeg Final destination: Cross Lake

Type of cargo: General merchandise (non-perishables)

Mode(s) of transport: Barge

Linkage(s) and mode(s) used: Winnipeg (Selkirk) to Cross Lake, via 2-Mile, 8-Mile and Ominawin By-pass Channels as well as possible Jenpeg lock, by barge

Seasonal nature: Summer

Weight (cwt)	Barge	Total Cost $
	Unit Rate $/cwt	
4000	2.60	10400
8000	2.60	20800
12000	2.60	31200
16000	2.60	41600
20000	2.60	52000
24000	2.60	62400
28000	2.60	72800
32000	2.60	83200

Estimated general inbound cargo to Cross Lake is 7000 cwt in Summer 1971 (Hudson Bay Co.).

Rate Source: Marine Transport Limited.

TABLE VIB27

INBOUND CARGO

Method 5:

Origin: Winnipeg Final destination: Cross Lake

Type of cargo: General merchandise (non-perishables)

Mode(s) of transport: Barge and portage

Linkage(s) and mode(s) used: From Winnipeg (Selkirk) by barge to Whiskey Jack Portage and by truck and barge to Cross Lake

Seasonal nature: Summer only

Weight (cwt)	Barge (To Whiskey Jack Por)		Barge and Truck (To Cross Lake)		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
4000	2.50	10000	1.50	6000	16000
8000	2.50	20000	1.50	12000	32000
12000	2.50	30000	1.50	18000	48000
16000	2.50	40000	1.50	24000	64000
20000	2.50	50000	1.50	30000	80000
24000	2.50	60000	1.50	36000	96000
28000	2.50	70000	1.50	42000	112000
32000	2.50	80000	1.50	48000	128000

Estimated general cargo inbound to Cross Lake is 7000 cwt in Summer 1971 (Hudson Bay Co.).

Rate Sources: Marine Transport Limited, Cross Lake Transportation Study, M.M. Dillon and Associates.

TABLE VIB28

INBOUND CARGO

Method 6:

Origin: Winnipeg Final destination: Cross Lake

Type of cargo: General merchandise (non-perishables)

Mode(s) of transport: Air

Linkage(s) and mode(s) used: Winnipeg to Cross Lake by air direct.

Seasonal nature: Winter and summer

Weight (cwt)	Air Unit Rate $/cwt	Total Cost $
4000	12.00	48000
8000	12.00	96000
12000	12.00	144000
16000	12.00	192000
20000	12.00	240000
24000	12.00	288000
28000	12.00	336000
32000	12.00	384000

Estimated general cargo inbound to Cross Lake 23000 cwt in 1971 (Hudson Bay Co.).

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VIB29

INBOUND CARGO

Method 7:

Origin: Winnipeg Final destination: Cross Lake

Type of cargo: General merchandise (non-perishables)

Mode(s) of transport: Truck and barge

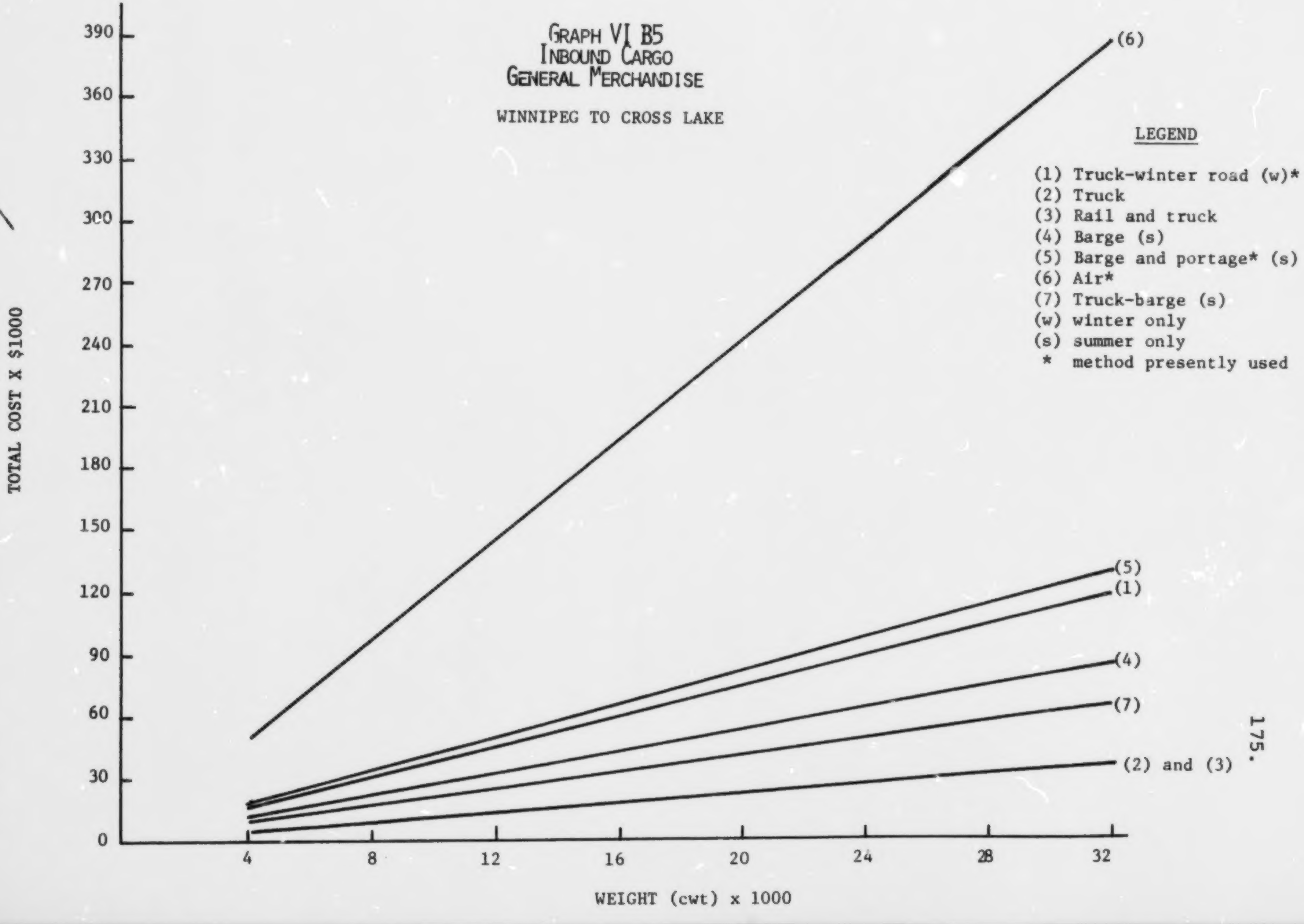
Linkage(s) and mode(s) used: Winnipeg to Minago River (Jenpeg access road) by truck and Minago River to Cross Lake by barge

Seasonal nature: Summer only

Weight (cwt)	Truck		Barge		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
4000	1.03	4120	1.00	4000	8120
8000	1.03	8240	1.00	8000	16240
12000	1.03	12360	1.00	12000	24360
16000	1.03	16480	1.00	16000	32480
20000	1.03	20600	1.00	20000	40000
24000	1.03	24720	1.00	24000	48720
28000	1.03	28840	1.00	28000	56840
32000	1.03	32960	1.00	32000	64960

Estimated general cargo inbound to Cross Lake is 23000 cwt in 1971 (Hudson Bay Co.).

Rate Sources: Manitoba Department of Industry and Commerce, Cross Lake Transportation Study, M.M. Dillon and Associates (barge rate estimate).



GRAPH VI B5
INBOUND CARGO
GENERAL MERCHANDISE

WINNIPEG TO CROSS LAKE

Transportation cost analysis for general cargo to Cross Lake

Method 1:

Winnipeg to Jenpeg by all-weather road (truck) and Jenpeg to Cross Lake by winter road (truck).

1. Hydro inputs available:
   (a) Jenpeg access road
2. Hydro inputs required: Nil
3. Other inputs required:
   (a) Winter road from Jenpeg to Cross Lake
4. General shipping costs for potential traffic (annual):
   Amount (1971-72): 23000 cwt Cost: $83,000
5. Rank of method:
   Fifth of seven methods
6. Hydro development impact on method:
   Due to the accessibility provided by the Jenpeg access road, the impact on this method of importation is beneficial.

Method 2:

Winnipeg to Cross Lake (including possible Jenpeg-Cross Lake road) by truck.

1. Hydro inputs available:
   (a) Jenpeg access road
   (b) Jenpeg control structure - bridgehead

2. Hydro inputs required: Nil
3. Other inputs required:
   (a) Jenpeg access road extension to Cross Lake
4. General shipping costs for potential traffic (annual):
   Amount (1971-72): 23000 cwt Cost: $24,000
5. Rank of method:
   First of seven methods (tied)
6. Hydro development impact on method:
   Hydro development has a major beneficial impact on the potential utilization of this method, having provided the greatest portion of the infrastructure in the Outlet Lakes area necessary for importation.

Method 3:

Winnipeg to Wabowden by rail for transshipment and furtherance to Cross Lake (including possible Jenpeg-Cross Lake road) by truck.

1. Hydro inputs available:
   (a) Jenpeg access road
   (b) Jenpeg control structure - bridgehead
2. Hydro inputs required: Nil
3. Other inputs required:
   (a) Jenpeg access road extension to Cross Lake

4. General shipping costs for potential traffic (annual):

   Amount (1971-72): 23000 cwt Cost: $24,000

5. Rank of method:

   First of seven methods (tied).

6. Hydro development impact on method:

   Similar to method two.

Method 4:

Winnipeg or Selkirk by barge to Cross Lake via the 2-Mile and 8-Mile Channels, the Ominawin Bypass and a possible lock at Jenpeg.

1. Hydro inputs available:
   (a) 2-Mile Channel
   (b) 8-Mile Channel
   (c) Ominawin Bypass
   (d) Jenpeg control structure
2. Hydro inputs required:
   (a) Provision for a lock in the Jenpeg structure
3. Other inputs required:
   (a) Lock in the Jenpeg control structure
4. General shipping cost for potential traffic (annual):

   Amount (1971-72): 23000 cwt Cost: $60,000

5. Rank of method:

   Fourth of seven methods

6. Hydro development impact on method:

Hydro development has a major beneficial impact on this method, providing the necessary navigational improvements (2-Mile and 8-Mile Channels, Ominawin Bypass) necessary for utilization of this importation procedure.

Method 5:

From Winnipeg or Selkirk by barge (via 2-Mile Channel) to Whiskey Jack Portage for transshipment and furtherance to Cross Lake by truck and small barge.

1. Hydro inputs available:
   (a) 2-Mile Channel
2. Hydro inputs required: Nil
3. Other inputs required:
   (a) Raising Whiskey Jack Portage wharves to an elevation above maximum regulated level
4. General shipping cost for potential traffic (annual):
   Amount (1971-72): 23000 cwt Cost: $93,000
5. Rank of method:
   Sixth out of seven methods
6. Hydro development impact on method:
   Provision of the 2-Mile Channel as an alternative to the hazardous Warren Landing approach is a beneficial impact. This is offset by the necessity of raising the

Whiskey Jack Portage wharves above maximum regulated flood stage.

Method 6:

Winnipeg to Cross Lake by aircraft.

1. Hydro inputs available: Nil
2. Hydro inputs required: Nil
3. Other inpurs required: Nil
4. General shipping cost for potential traffic (annual):
   Amount (1971-72): 3000 cwt Cost: $280,000
5. Rank of method:
   Seventh of seven methods.
6. Hydro development impact on method.
   Hydro development does not affect this method.

Method 7:

Winnipeg to the Minago River crossing of the Jenpeg access road by truck for transshipment to small barge and furtherance to Cross Lake.

1. Hydro inputs available:
   (a) Jenpeg access road
2. Hydro inputs required: Nil
3. Other inputs required:
   (a) Wharf facility at the Minago River crossing

4. General shipping cost for potential traffic (annual):

   Amount (1971-72): 23000 cwt Cost: $46,000

5. Rank of method:

   Third out of seven methods

6. Hydro development impact on method:

   Due to the accessibility provided by the Jenpeg access road, the impact on this method of importation is beneficial.

TABLE VIB30

INBOUND CARGO

Method 1:

Origin: Regina Final destination: Cross Lake

Type of carço: Fuel oil

Mode(s) of transport: Rail and truck

Linkage(s) and mode(s) used: Regina to Wabowden by rail and Wabowden to Cross Lake by truck via Jenpeg access road and extension

Seasonal nature: Summer and winter

Weight (cwt)	Rail		Truck		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
40000	1.02	40800	.29	11600	52400
45000	1.02	45900	.29	13050	58950
50000	1.02	51000	.29	14500	65500
55000	1.02	56100	.29	15950	72050
60000	1.02	61200	.29	17400	78600
65000	1.02	66350	.29	18830	85180
70000	1.02	71400	.29	20300	91700
75000	1.02	76500	.29	21750	98250
80000	1.02	81600	.29	23200	104800
85000	1.02	86700	.29	24600	111300
90000	1.02	91800	.29	26100	117900
95000	1.02	96900	.29	27500	124400

Note: There is no figure availabel on the amount of fuel oil shipped to Cross Lake annually however, the figure of 750,000 gallons is considered reasonable by the Manitoba Department of Industry and Commerce.

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VIB31

INBOUND CARGO

Method 2:

Origin: Winnipeg Final destination: Cross Lake

Type of cargo: Fuel oil

Mode(s) of transport: Truck

Linkage(s) and mode(s) used: Winnipeg to Cross Lake via Jenpeg access road and possible extension

Seasonal nature: Summer and winter

Weight (cwt)	Truck Unit Rate $/cwt	Total Cost $
40000	1.05	42000
45000	1.05	47200
50000	1.05	52500
55000	1.05	57700
60000	1.05	63000
65000	1.05	68200
70000	1.05	73500
75000	1.05	78700
80000	1.05	84000
85000	1.05	89200
90000	1.05	94500
95000	1.05	99700

Rate Source: Manitoba Department of Industry and Commerce.

TABLE VIB32

INBOUND CARGO

Method 3:

Origin: Winnipeg Final destination: Cross Lake

Type of cargo: Fuel oil

Mode(s) of transport: Barge

Linkage(s) and mode(s) used: Winnipeg (Selkirk) to Cross Lake by barge via a possible lock at Jenpeg

Seasonal nature: Summer only

Weight (cwt)	Barge	Total Cost $
	Unit Rate $/cwt	
40000	1.50	60000
45000	1.50	67500
50000	1.50	75000
55000	1.50	82500
60000	1.50	90000
65000	1.50	97500
70000	1.50	105000
75000	1.50	112500
80000	1.50	120000
85000	1.50	127500
90000	1.50	135000
95000	1.50	142500

Rate Source: Marine Transport Limited, 1972.

TABLE VIB33

INBOUND CARGO

Method 4:

Origin: Winnipeg Final destination: Cross Lake

Type of cargo: Fuel oil

Mode(s) of transport: Barge and portage

Linkage(s) and mode(s) used: Winnipeg to Cross Lake by barge with transshipment via Whiskey Jack Portage

Seasonal nature: Summer only

Weight (cwt)	Barge		Barge		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
40000	1.50	60000	1.50	60000	120000
45000	1.50	67500	1.50	67500	135000
50000	1.50	75000	1.50	75000	150000
55000	1.50	82500	1.50	82500	165000
60000	1.50	90000	1.50	90000	180000
65000	1.50	97500	1.50	97500	195000
70000	1.50	105000	1.50	105000	210000
75000	1.50	112500	1.50	112500	225000
80000	1.50	120000	1.50	120000	240000
85000	1.50	127500	1.50	127500	255000
90000	1.50	135000	1.50	135000	270000
95000	1.50	142500	1.50	142500	285000

Note: The rate of $1.50 for the Whiskey Jack-Cross Lake connection was taken from the general merchandise rate quoted in the M.M. Dillon Report.

Rate Source: Marine Transport Limited and M.M. Dillon and Associates Limited, 1972.

TABLE VIB34

INBOUND CARGO

Method 5:

Origin: Winnipeg Final destination: Cross Lake

Type of cargo: Fuel oil

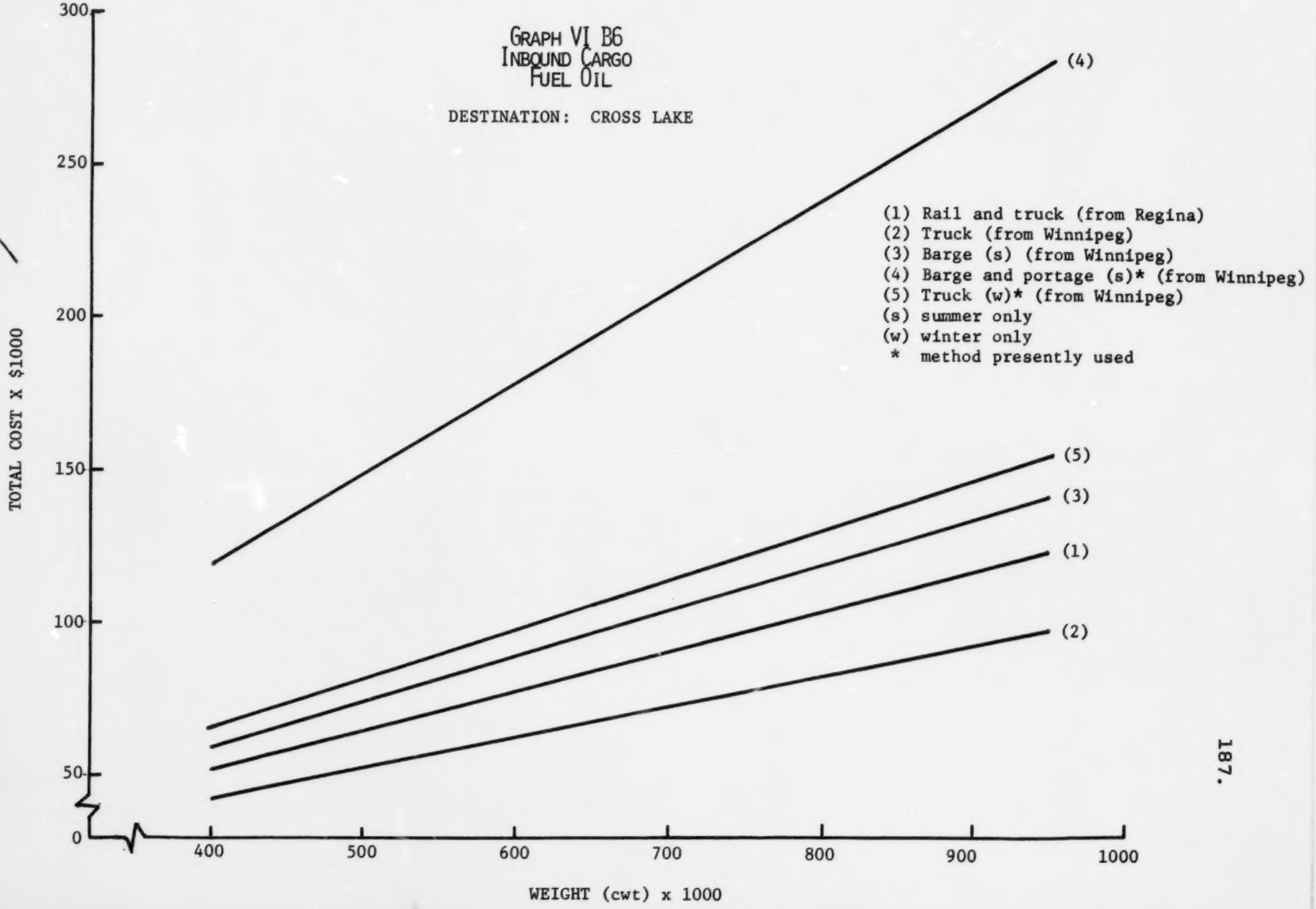
Mode(s) of transport: Truck (winter)

Linkage(s) and mode(s) used: Winnipeg to Jenpeg by truck and Jenpeg to Cross Lake by winter road (truck)

Seasonal nature: Winter only

Weight (cwt)	Truck		Truck (Winter)		Total Cost $
	Unit Rate $/cwt	Subtotal $	Unit Rate $/cwt	Subtotal $	
40000	1.05	42000	.60	24000	66000
45000	1.05	47200	.60	27000	74200
50000	1.05	52500	.60	30000	82500
55000	1.05	57700	.60	33000	90700
60000	1.05	63000	.60	36000	99000
65000	1.05	68200	.60	39000	107200
70000	1.05	73500	.60	42000	115500
75000	1.05	78700	.60	45000	123700
80000	1.05	84000	.60	48000	132000
85000	1.05	87200	.60	51000	140200
90000	1.05	94500	.60	54000	148500
95000	1.05	99700	.60	57000	156700

Rate Source: Manitoba Department of Industry and Commerce.



GRAPH VI B6
INBOUND CARGO
FUEL OIL

DESTINATION: CROSS LAKE

Transportation cost analysis for fuel oil to Cross Lake

Method 1:

Movement of fuel oil from Regina to Wabowden by rail and transshipment to truck for furtherance to Cross Lake via the Jenpeg access road and the Cross Lake extension.

1. Hydro inputs available:
   (a) Jenpeg access road
   (b) Jenpeg control structure - bridgehead
2. Hydro inputs required: Nil
3. Other inputs required:
   (a) Extension of Jenpeg access road to Cross Lake
4. General shipping cost for potential traffic (annual):
   Amount (1972): 75000 cwt Cost: $98,250
5. Rank of method:
   Second out of five methods
6. Hydro development impact on method:
   Hydro development has a major beneficial impact on this method of removal by providing the initial stage of accessibility.

Method 2:

Winnipeg to Cross Lake by truck via PTH6, the Jenpeg access road and its possible extension to Cross Lake.

1. Hydro inputs available:

   (a) Jenpeg access road

   (b) Jenpeg control structure - bridgehead

2. Hydro inputs required: Nil

3. Other inputs required:

   (a) Extension of Jenpeg access road to Cross Lake

4. General shipping cost for potential traffic (annual):

   Amount (1972): 750000 cwt   Cost: $78,700

5. Rank of method:

   First out of five methods

6. Hydro development impact on method:

   Same as method one.

Method 3:

Winnipeg to Cross Lake by barge and/or boat via a possible lock at Jenpeg, the Ominawin Bypass, the 8-Mile Channel and the 2-Mile Channel (summer only).

1. Hydro inputs available:

   (a) Jenpeg control structure

   (b) Ominawin Bypass

   (c) 8-Mile Channel

   (d) 2-Mile Channel

2. Hydro inputs required:

   (a) Right-of-way for lock in Jenpeg structure

3. Other inputs required:

   (a) Jenpeg control structure lock

4. General shipping cost for potential traffic (annual):

   Amount (1972): 750000 cwt Cost: $112,500

5. Rank of method:

   Third out of five methods

6. Hydro development impact on method:

   Hydro development has a major beneficial impact on the potential utilization of this method, since it has provided or will be providing the channel improvements necessary as in initial stage in its availability.

Method 4:

Winnipeg to Cross Lake by barge and/or boat with transshipment to truck for the Whiskey Jack Portage (summer only).

1. Hydro inputs available:

   (a) 2-Mile Channel

2. Hydro inputs required: Nil

3. Other inputs required:

   (a) Raising Whiskey Jack Portage wharves to higher elevation

4. General shipping cost for potential traffic (annual):

   Amount (1972): 750000 cwt Cost: $225,000

5. Rank of method:

   Fifth out of five methods

6. Hydro development impact on method:

   Provision of the 2-Mile Channel, as an alternative to the hazardous Warren Landing approach, is a beneficial impact on Hydro development. This is offset by the necessity of raising the Whiskey Jack Portage wharves above the maximum regulated flood stage.

Method 5:

Winnipeg to Cross Lake by truck via PTH6, the Jenpeg access road and a winter truck road connecting Jenpeg to Cross Lake (winter only).

1. Hydro inputs available:
   (a) Jenpeg access road
   (b) Jenpeg control structure - bridgehead
2. Hydro inputs required: Nil
3. Other inputs required: Nil
4. General shipping cost for potential traffic (annual):

   Amount (1972): 750000 cwt Cost: $123,700

5. Rank of method:

   Fourth out of five methods

6. Hydro development impact on method:

   Hydro development has a major impact on this method of removal by providing the initial stage of accessibility.

VII TRANSPORTATION ALTERNATIVES AS A RESULT OF HYDRO DEVELOPMENT

This section examines the various aspects of an extended transportation-navitagtion system in the Outlet Lakes area, facilitated by Hydro development. Discussion will be limited to extensions and/or improvements to land and water transportation. The air transportation component is not affected, in terms of route alterations, by Hydro development.

A. Land transportation

(1) Jenpeg-Cross Lake Connection:

(a) Route alternatives (Map XVI):

i) A direct, all-weather road connection, via ten miles of roadway and two miles of causeway and/or bridges from the Jenpeg control structure - bridgehead to the community of Cross Lake.

Advantages of route (i):

- shortest possible route to Cross Lake community
- available for year-round travel
- avoids encroachment on the passive recreation area (section VC)

Disavantages of route (i):

- high capital cost due to length of causeways and/or bridges required

ii) An all-weather road connection approximately 20 miles in length, via a crossing (or crossings) of the outlet of Pipestone Lake, from the Jenpeg control structure - bridgehead to Cross Lake community.

Advantages of route (ii):

- involves fewer water crossings than alternative (i)
- available for year-round travel

Disadvantages of route (ii):

- longer than alternative (i)
- encroaches on the northern extremity of the passive recreation area
- high capital cost due to length of roadway

iii) An all-weather road from the Jenpeg site to the Cross Lake side of Whiskey Jack Portage coupled with a ferry service from this point to Cross Lake community.

Advantages of route (iii):

- lower capital cost due to reduced road construction
- could utilize the now-idle Hecla Island ferry
- does not encroach on passive recreation area

Disadvantages of route (iii):

- longer than alternative (i)
- available during ice-free months only
- requires greater length of time to reach Cross Lake than either of the other alternatives

- limited in the size of vehicle it is able to accomodate due to the capacity of ferry

(b) Advantages of Jenpeg-Cross Lake connection

i) Removal of pulpwood and fish from the Cross Lake area via this connection by truck and rail and/or truck involves the lowest transportation cost (Graphs VB2, VB3 and VA1).

ii) Importation of perishables, general merchandise and fuel oil by this connection (utilizing trucking) has the lowest transportation cost (Graphs VIB4, VIB5, VIB6).

iii) This connection will eliminate the land isolation component for the 2,000 residents of Cross Lake.

(c) Disadvantages of the Jenpeg-Cross Lake connection

i) Each alternative requires a certain amount of road construction which is made difficult by the sections of bog, fen and swamp which are found throughout the Outlet Lakes area. Map XV illustrates the general classification of the area through which each of the alternative roadways pass with regard to highway construction capability.

ii) High capital cost involved in providing the infrastructure necessary for each alternative.

iii) Construction of any of the alternatives will not be undertaken by Hydro, but will require additional expenditures.

(2) Jenpeg-Norway House connection

(a) Route location: An all-weather road from Jenpeg to Norway House via Ross Island and an East Channel control structure - bridgehead, will connect this community to the Provincial highway system (Map XVI). This route is considered to be the most likely choice due to the availability of suitable terrain for roadway construction along its proposed alignment. Map XV identifies this suitable construction area.

With regard to the proposed East Channel control structure, no location has been confirmed by Hydro. However, the Sea River Falls area has certain characteristics which lend itself to being a likely choice for this location (section IIID). Therefore, it will be considered as the East Channel control structure site in this section. Construction activity at the East Channel control structure site may necessitate some form of surface accessibility, to be initiated by Hydro. This accessibility could be provided either by extension of the Jenpeg access road to the site (to service the construction activity via all-weather road) or by an all-weather road from Norway House integrated with marine freighting from Winnipeg (Selkirk).

In each of the above alternatives Hydro development has provided an initial major link in the Jenpeg-Norway House construction.

(b) Advantages:

i) Removal of fish from the Norway House area by truck, via this connection, involves the lowest transportation cost (Graph VA2).

ii) Removal of pulpwood from the area of Norway House by truck (to the Wabowden rail head) using this connection involves the lowest pulpwood transportation cost (Graph VB1).

iii) Importation of perishables, general merchandise and fuel oil by this road connection(utilizing truck or rail and truck integration) has the lowest transportation cost (Graphs VIB1, VIB2, VIB3).

iv) This road connects the community of Norway House to the Provincial highway network thereby eliminating its land isolation component.

v) Does not encroach on the passive recreation area while providing the limited accessibility required by this area.

vi) Provides, in conjunction with the Jenpeg-Cross Lake connection, improved intra-regional accessibility.

(c) Disadvantages:

i) Construction of the roadway is made difficult due to certain areas of bog, fen and swamp which are found in the northern half of Ross Island. Construction is further complicated by numerous rock outcrops which follow the east shore of the East Channel.

ii) The alignment of the road along the east shore of the East Channel must follow the basic configuration of the shoreline due to the presence of much swamp, fen and bog within approximately one-half mile of the water's edge.

iii) Construction of such a road requires a high capital cost input.

(3) Jenpeg-Kiskitto Dam connection

(a) Route location: An all-weather road connection from Jenpeg to the Kiskitto Dam area, via an extension of the Ominawin access road along the West Channel of the Nelson River.

(b) Advantages:

i) Removal of pulpwood from the Kiskitto Dam area (Kiskittogisu-Forest Management Area 82) by either truck to The Pas or truck to the Wabowden rail head using this connection involves the lowest transportation cost (Graph VB2).

ii) Provides accessibility to the proposed recreation area on the north-east shore of Kiskitto Lake (section VC).

(c) Disadvantages:

i) Construction of the roadway is made difficult due to the nature of the terrain, necessitating high capital cost.

B. Water transportation

(1) Winnipeg (Selkirk)-Norway House connection

(a) Route description: From Winnipeg or Selkirk by boat or barge, via Lake Winnipeg, the 2-Mile Channel and Playgreen Lake, to Norway House.

(b) Advantages:

i) Removal of pulpwood from the Norway House area by barge involves the second lowest (of three) transportation cost (Graph VB1).

ii) Removal of fish from the lakes in the Norway House area by barge involves the third lowest (of six) transportation cost (Graph VA2).

iii) Importation of general merchanidse by this route by barge has the second lowest (of four) transportation cost (Graph VIB2).

iv) Involves no added expenses due to major extension of infrastructure.

v) Utilization of the 2-Mile Channel route bypasses the hazardous Warren Landing approach.

vi) Utilization of this route may remove the necessity of transshipment to smaller vessels at Warren Landing, in times of low water.

(c) Disadvantages:

i) Some expenditure may be required to construct a breakwater and install navigational aids in the 2-Mile Channel (section IVD2).

ii) Transportation costs for importation of perishables and fuel oil are higher for this route (Graphs VIB1 and VIB3).

iii) Route available during ice-free season only.

(2) Winnipeg (Selkirk)-Cross Lake (via Whiskey Jack) connection

(a) Route description: From Winnipeg or Selkirk by boat or barge to Cross Lake, via Lake Winnipeg, the 2-Mile Channel and the Whiskey Jack Portage.

(b) Advantages:

i) Involves no added expense due to major extension of infrastructure.

ii) Utilization of 2-Mile Channel route bypasses hazardous Warren Landing approach.

iii) Utilization of this route may remove the necessity of transshipment to smaller vessels at Warren Landing in times of low water.

(c) Disadvantages:

i) Transportation costs for the importation of perishables general merchandise and fuel oil are higher for this route (Graphs VIB1, VIB2, and VIB3) than for other methods.

iii) Some expenditure may be required to construct a breakwater and install navigational aids in the 2-Mile Channel (section IVD2).

iv) Route available during ice-free seasons only.

(3) Winnipeg (Selkirk) Cross Lake (via Jenpeg Portage) connection

(a) Route description: From Winnipeg or Selkirk by boat or barge to Cross Lake via Lake Winnipeg, the 2-Mile Channel, Playgreen Lake and/or the 8-Mile Channel, the Ominawin Bypass and a minor portage at Jenpeg.

(b) Advantages:

i) Use of the 2-Mile Channel bypasses hazardous Warren Landing approach.

ii) Reduced length of portage.

iii) Reduction in transportation costs over the Whiskey Jack Portage route.

iv) Removes the necessity of transshipment to smaller vessels at Warren Landing in times of low water.

(c) Disadvantages:

i) Some expenditure may be required to construct a breakwater at the 2-Mile Channel and install navigational aids in the 2-Mile and 8-Mile Channels and the Ominawin

Bypass.

ii) Expenditure required to construct wharf facilities at Jenpeg.

iii) Route available during ice-free season only.

(4) Winnipeg (Selkirk)-Cross Lake (via lock at Jenpeg) connection

(a) Route description: From Winnipeg or Selkirk by boat or barge to Cross Lake via Lake Winnipeg, the 2-Mile Channel, Playgreen Lake and/or the 8-Mile Channel, The Ominawin Bypass and a Jenpeg control structure lock.

(b) Advantages:

i) Use of the 2-Mile Channel bypasses the hazardous Warren Landing approach.

ii) Eliminates the necessity for a portage thereby reducing handling costs.

iii) Removes the necessity of transshipment to smaller vessels at Warren Landing in times of low water.

iv) Importation transportation costs are lower than other marine routes (Graphs VIB4, VIB5, VIB6).

v) Large volume resource product removal by barge from the Cross Lake area is made possible. Transportation costs for such removal are second lowest of all methods for both fish and pulpwood (Graphs VA1 and VB3).

vi) Route facilitates extension of present navigation route northward should marine traffic warrant such an extension.

(c) Disadvantages:

i) Requires large capital outlay for construction of a lock in the Jenpeg structure.

ii) Importation transportation costs are higher than any land based method other than winter truck road (Graphs VIB4, VIB5, VIB6).

iii) Transportation costs for removal of both fish and pulpwood are higher than some land based methods (Graphs VA1, VB3).

iv) Some expenditure may be required to construct a breakwater at the 2-Mile Channel and install navigational aids in the 2-Mile Channel, the 8-Mile Channel and the Ominawin Bypass.

v) Route available during ice-free season only.

VIII CONCLUSIONS

As a result of this study, a number of conclusions may be drawn with regard to the effect of Hydro development on transportation and navigation in the Outlet Lakes area.

(a) Connection of the communities in the Outlet Lakes area with the rest of Manitoba by land is facilitated as a result of the Jenpeg access road.

(b) Removal of resource products (i.e. fish and pulpwood) will be made less expensive by the extension of: the Ominawin access road to the Kiskitto Dam site; the Jenpeg access road to Cross Lake community; and the Jenpeg access road (via the East Channel control structure) to Norway House (based on the existing cost structure and estimates).

(c) Importation of all types of cargo to the communities of Cross Lake and Norway House will also be made less expensive by the road extensions mentioned in (b) above, based on existing cost structure and estimates.

(d) Importation of cargo to Cross Lake may be accomplished using trucks by means of the Jenpeg access road as far as the Minago River crossing where it would be transshipped to barge for furtherance to Cross Lake. This method would be less expensive (based on existing cost structure and estimates) than use of barge via the Whiskey Jack Portage for commodities other than fuel oil.

(e) Terrain conditions in the Outlet Lakes area are characteristic of most regions of northern Manitoba and consequently necessitate above average highway construction and maintenance cost.

(f) All requirements for accessibility by land to the proposed East Channel recreation area would be provided by the use of a possible Sea River Falls crossing of the Jenpeg-Norway House road as the point of ingress.

(g) With the advent of the Jenpeg forebay and construction of the 2-Mile Channel, the 8-Mile Channel and Ominawin Bypass, navigation in the Outlet Lakes will be possible as far as the Jenpeg site.

(h) The diversion channels, mentioned above in (g), may require certain navigational aids. The 2-Mile Channel may also require a breakwater on the Lake Winnipeg side to prevent silting.

(i) The more hazardous Warren Landing approach will likely be abandoned in favor of the 2-Mile Channel for vessels entering or leaving Playgreen Lake.

(j) Use of the Warren Landing wharf may be restricted to providing shelter for vessels entering Lake Winnipeg in times of storms; the alternative is construction of a wharf on the Playgreen Lake side of the 2-Mile Channel.

(k) Of the wharves inventoried those subject to flooding as a result of regulation include:

(1) the lower level of the Rossville wharf (deck elevation 714.3 feet)

(2) the southern wharf of the Whiskey Jack Portage (deck elevation 713.5 feet)

(3) the northern wharf of the Whiskey Jack Portage (deck elevation 685.0 feet) will be subject to periodic wash.

(l) Information is lacking with regard to the approach depths of all wharves in the Outlet Lakes, therefore no conclusion can be reached as to the effects of low water levels.

(m) The existing all-weather roads, airstrips and the Hudson Bay Railway line will not be affected physically by Hydro development.

(n) Changes in current flow and the resultant alteration in freeze-thaw cycle as well as fluctuations in water levels could affect the time of use of the sea plane bases at Cross Lake and Norway House.

(o) Fluctuations in water levels and current flow, resulting in possible modifications to ice formation, could affect the winter road from PTH6 to Norway House where it crosses Playgreen Lake, and the winter road from Jenpeg to Cross Lake in the vicinity of the community of Cross Lake.

(p) As stated in section IVF2, approximately 3,400 feet of road in the community of Cross Lake, representing about 16 percent of the total local road network, will be flooded during periods of high water levels (elevation 685.0 feet) as a result of Hydro development.

(q) No decision can be made with regard to a lock in the Jenpeg control structure without a detailed benefit-cost analysis of the potential demand (marine traffic) versus the capital cost involved for this facility. This detailed analysis is beyond the scope of this report.

(r) Without more specific information regarding the construction of an East Channel control structure, no conclusions can be drawn as to its effects on transportation and navigation in the Norway House area.

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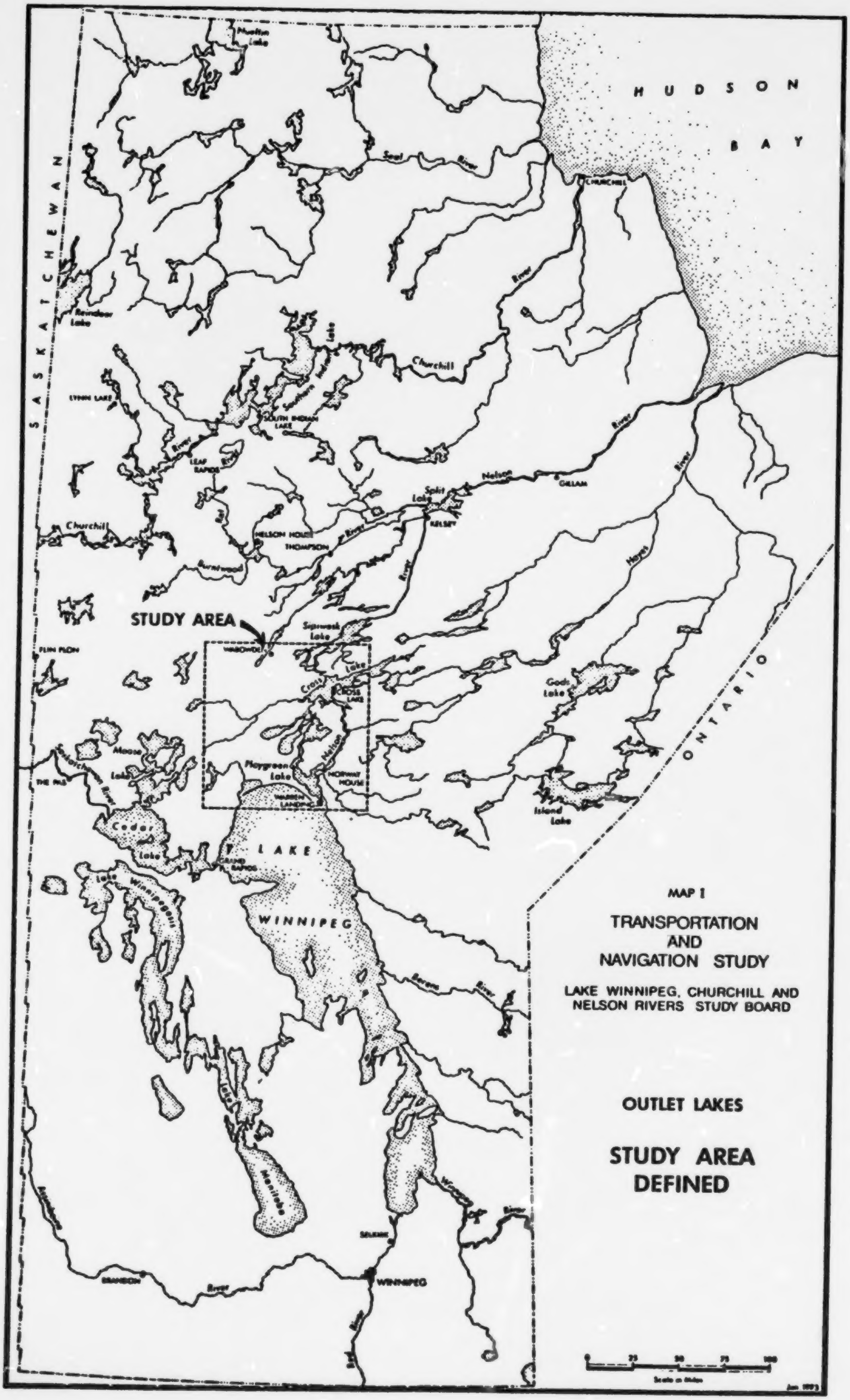
APPENDIX:
MAPS


HUDSON BAY
SASKATCHEWAN
ONTARIO
Nueltin Lake
Seal River
CHURCHILL
River
Reindeer Lake
Churchill
LYNN LAKE
SOUTH INDIAN LAKE
Southern Indian Lake
LEAF RAPIDS
River
Nelson
GILLAM
Split Lake
KELSEY
Churchill
NELSON HOUSE
THOMPSON
Burntwood
Rat
River
Hayes
STUDY AREA
Sipiwesk Lake
WABOWDEN
Cross Lake
CROSS LAKE
FLIN FLON
Gods Lake
Moose Lake
THE PAS
Saskatchewan River
Playgreen Lake
Nelson
NORWAY HOUSE
WARREN LANDING
Island Lake
Cedar Lake
GRAND RAPIDS
LAKE WINNIPEG
Lake Winnipegosis
Lake Manitoba
Berens River
Winnipeg
SELKIRK
WINNIPEG
BRANDON
River
Red River
0 25 50 75 100
Scale in Miles
Jan 1973

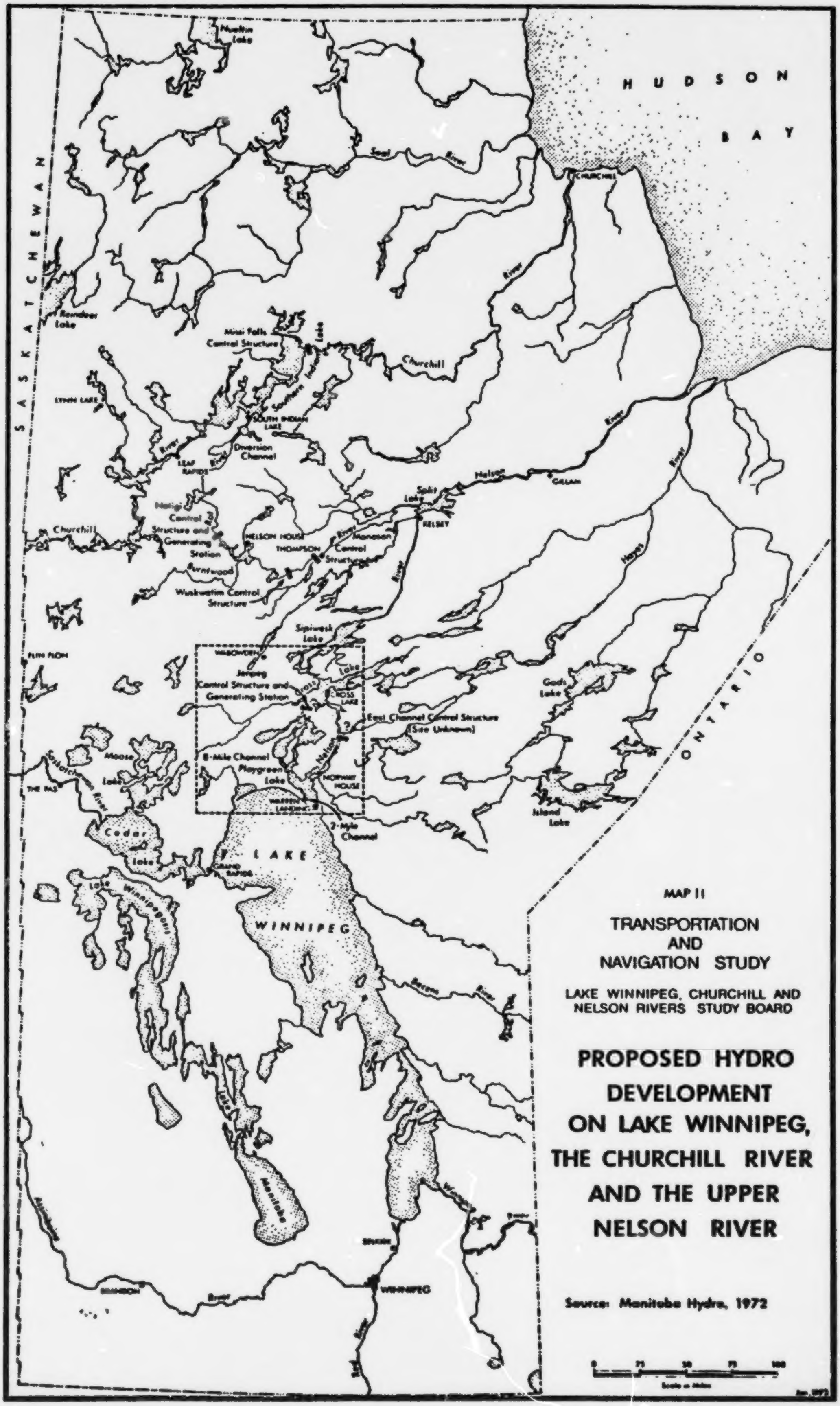
MAP 1

TRANSPORTATION
AND
NAVIGATION STUDY

LAKE WINNIPEG, CHURCHILL AND
NELSON RIVERS STUDY BOARD

OUTLET LAKES

STUDY AREA
DEFINED



HUDSON
BAY
SASKATCHEWAN
ONTARIO
Nueltin Lake
Seal River
CHURCHILL
River
Reindeer Lake
Missi Falls Control Structure
Southern Indian Lake
Churchill
LYNN LAKE
SOUTH INDIAN LAKE
River
Diversion Channel
LEAF RAPIDS
Rat
Notigi Control Structure and Generating Station
Churchill
NELSON HOUSE
THOMPSON
Manasan Control Structure
Burntwood
Wuskwatim Control Structure
River
Split Lake
KELSEY
Nelson
GILLAM
River
Hayes
River
Sipiwesk Lake
FLIN FLON
WABOWDEN
Jenpeg Control Structure and Generating Station
Cross Lake
CROSS LAKE
East Channel Control Structure (Site Unknown)
?
Gods Lake
Moose Lake
THE PAS
Saskatchewan River
8-Mile Channel
Playgreen Lake
Nelson
NORWAY HOUSE
WARREN LANDING
2-Mile Channel
Island Lake
Cedar Lake
GRAND RAPIDS
LAKE WINNIPEG
Lake Winnipegosis
Berens River
Lake Manitoba
Winnipeg River
SELKIRK
WINNIPEG
BRANDON
Assiniboine River
Red River
0 25 50 75 100
Scale in Miles

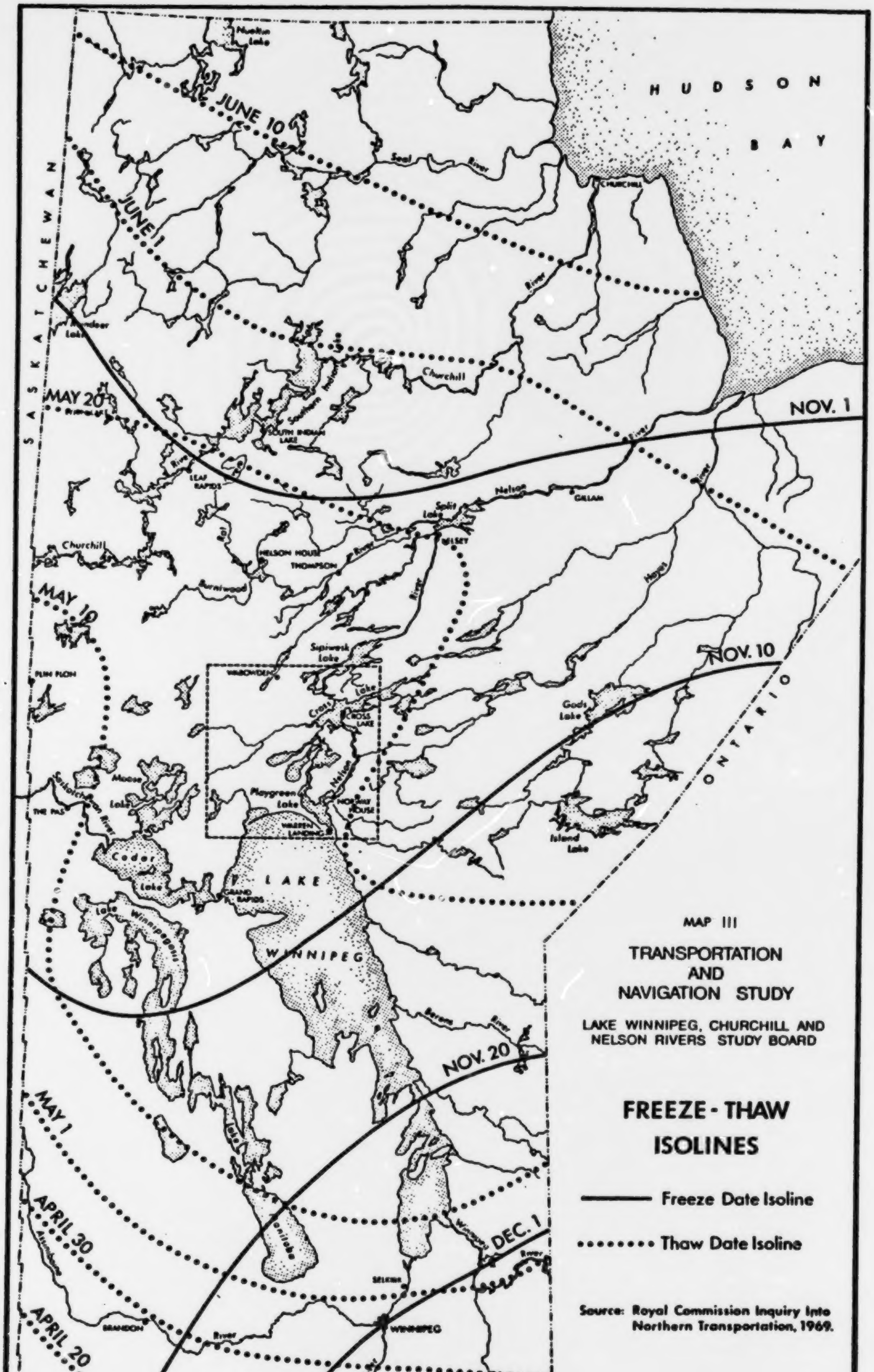
MAP 11

TRANSPORTATION
AND
NAVIGATION STUDY

LAKE WINNIPEG, CHURCHILL AND
NELSON RIVERS STUDY BOARD

PROPOSED HYDRO DEVELOPMENT ON LAKE WINNIPEG, THE CHURCHILL RIVER AND THE UPPER NELSON RIVER

Source: Manitoba Hydro, 1972


HUDSON BAY
SASKATCHEWAN
ONTARIO
JUNE 10
JUNE 11
MAY 20
MAY 10
MAY 1
APRIL 30
APRIL 20
NOV. 1
NOV. 10
NOV. 20
DEC. 1
Nueltin Lake
Seal River
CHURCHILL
Churchill
SOUTH INDIAN LAKE
LEAF RAPIDS
Nelson
GILLAM
Split Lake
KELSEY
NELSON HOUSE
THOMPSON
Burntwood
Hayes
Sipiwesk Lake
Cross Lake
CROSS LAKE
Gods Lake
Island Lake
FLIN FLON
THE PAS
Moose Lake
Cedar Lake
Playgreen Lake
NORWAY HOUSE
WARREN LANDING
GRAND RAPIDS
LAKE WINNIPEG
Lake Winnipegosis
Berens River
Manitoba
SELKIRK
WINNIPEG
BRANDON
Assiniboine River
Red River
Freeze Date Isoline
Thaw Date Isoline
0
25
50
75
100
Scale in Miles
Jan. 1973

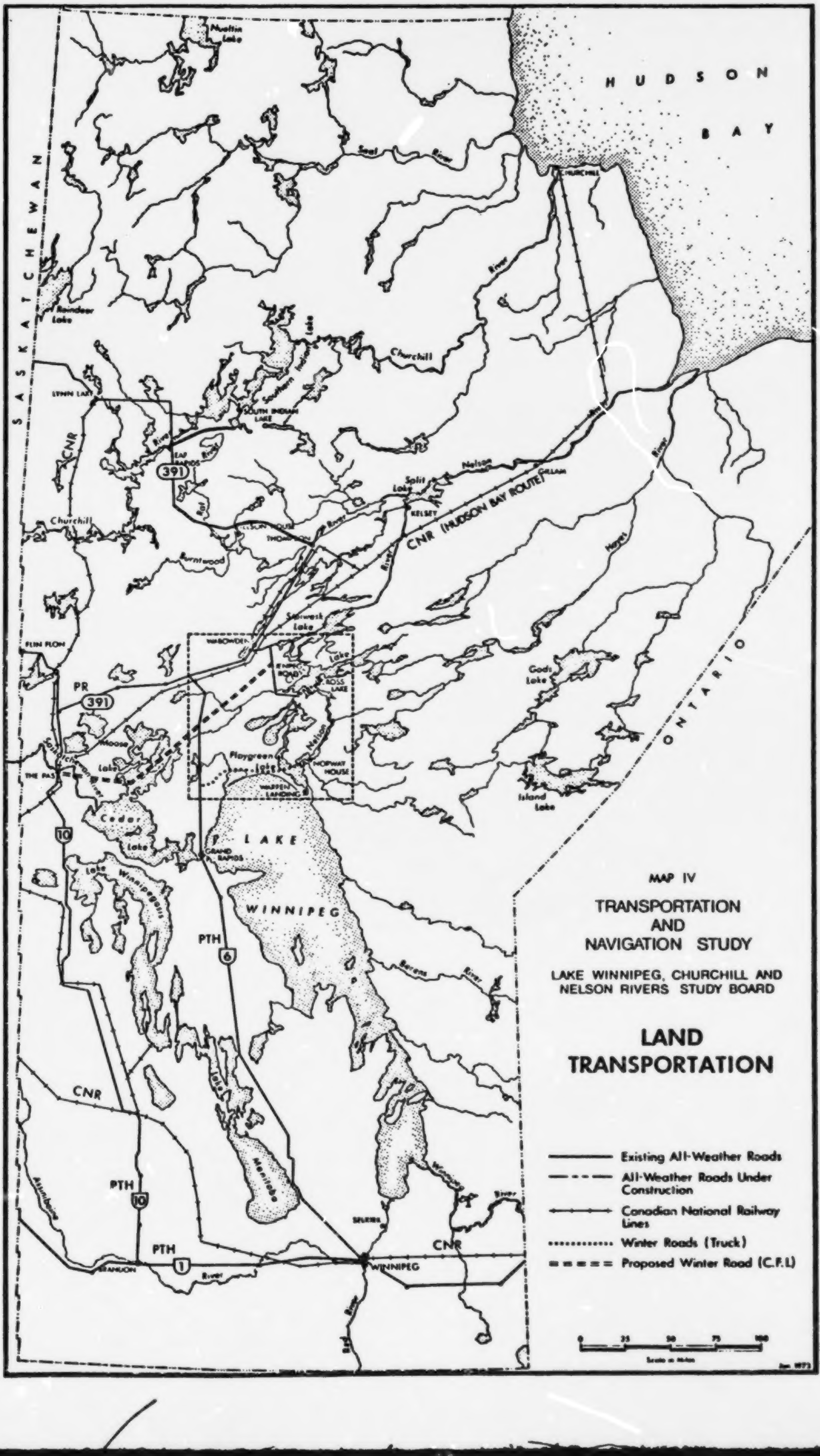
MAP III

TRANSPORTATION
AND
NAVIGATION STUDY

LAKE WINNIPEG, CHURCHILL AND
NELSON RIVERS STUDY BOARD

FREEZE - THAW
ISOLINES

Source: Royal Commission Inquiry Into Northern Transportation, 1969.



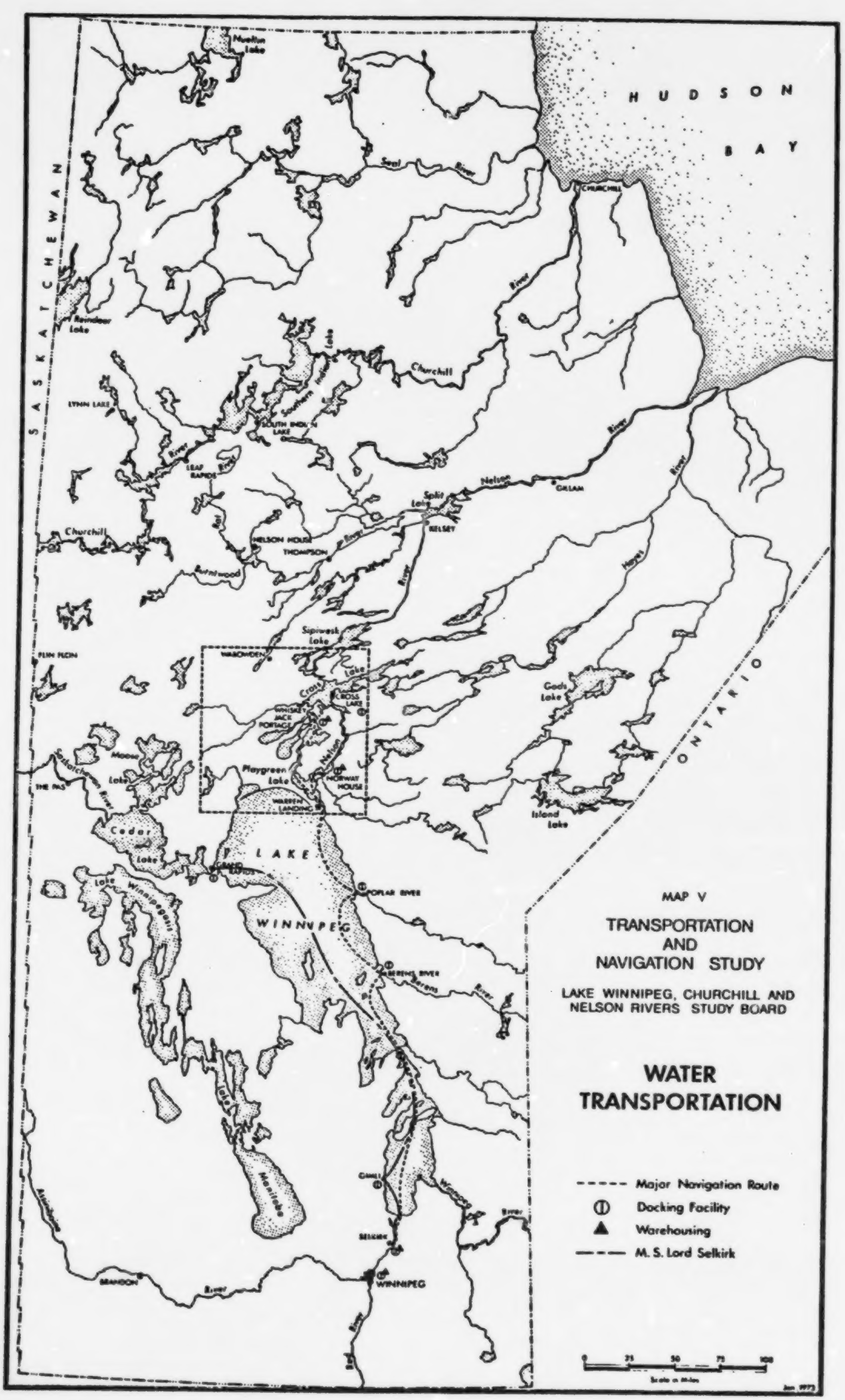
Nueltin Lake
HUDSON BAY
Seal River
CHURCHILL
SASKATCHEWAN
Reindeer Lake
Churchill
Southern Indian Lake
LYNN LAKE
SOUTH INDIAN LAKE
River
LEAF RAPIDS
391
CNR
Churchill
Rat
Burntwood
THOMPSON
Split Lake
KELSEY
Nelson River
GILLAM
CNR (HUDSON BAY ROUTE)
River
Hayes
Sipiwesk Lake
WABOWDEN
ROSS LAKE
Lake
FLIN FLON
PR 391
Moose Lake
THE PAS
Saskatchewan River
Playgreen Lake
Nelson
NORWAY HOUSE
WARREN LANDING
Gods Lake
Island Lake
ONTARIO
Cedar Lake
10
GRAND RAPIDS
LAKE WINNIPEG
Lake Winnipegosis
PTH 6
Berens River
Lake Manitoba
CNR
PTH 10
Assiniboine
PTH 1
BRANDON
River
SELKIRK
WINNIPEG
CNR
Winnipeg River
Red River
Existing All-Weather Roads
All-Weather Roads Under Construction
Canadian National Railway Lines
Winter Roads (Truck)
Proposed Winter Road (C.F.L)
0
25
50
75
100
Scale in Miles
Jan 1973

MAP IV

TRANSPORTATION
AND
NAVIGATION STUDY

LAKE WINNIPEG, CHURCHILL AND
NELSON RIVERS STUDY BOARD

LAND
TRANSPORTATION



MAP V

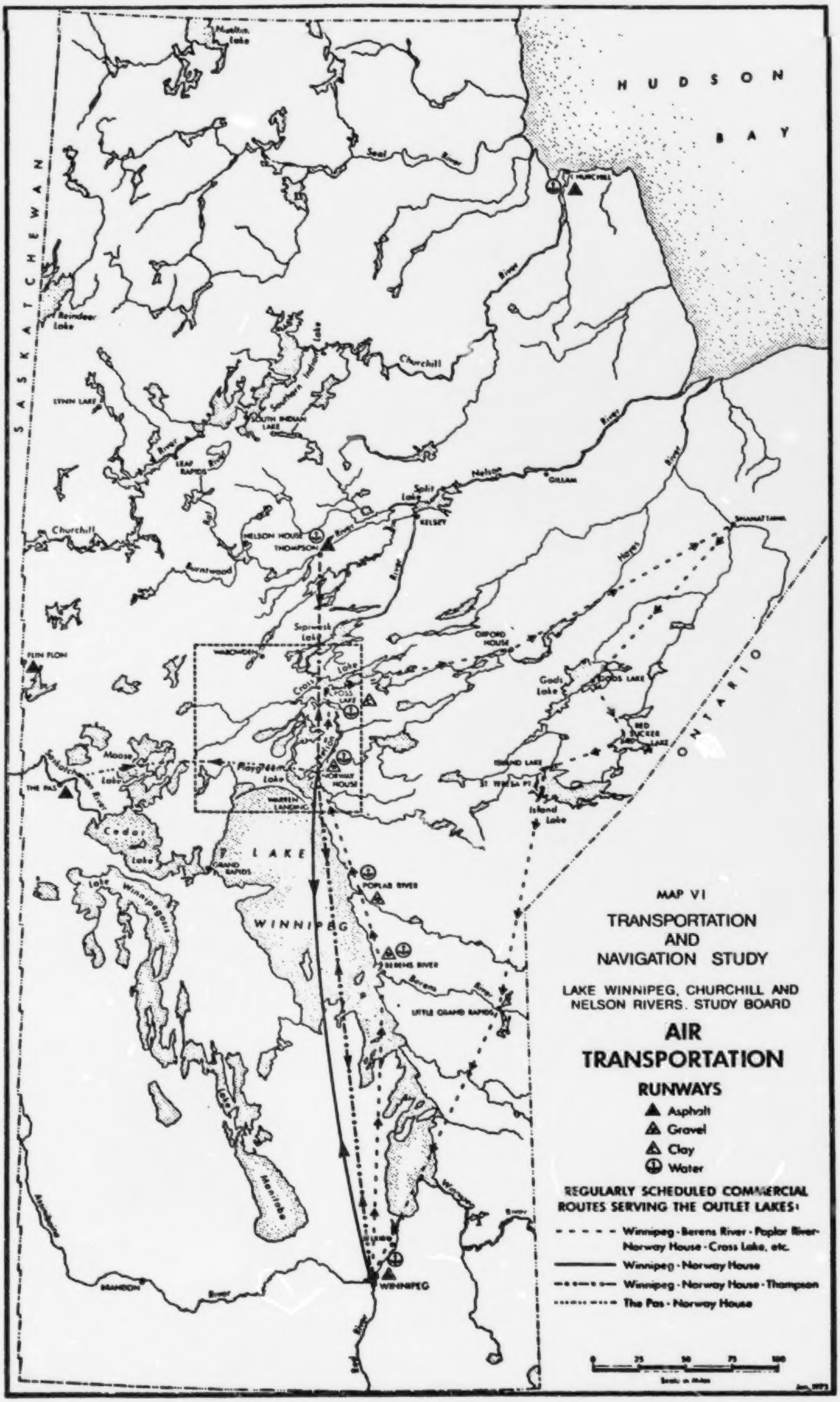
TRANSPORTATION AND NAVIGATION STUDY

LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

WATER TRANSPORTATION

HUDSON BAY
CHURCHILL
Nueltin Lake
Seal River
SASKATCHEWAN
Reindeer Lake
Churchill River
LYNN LAKE
SOUTH INDIAN LAKE
LEAF RAPIDS
Rat River
Churchill
NELSON HOUSE
THOMPSON
Burntwood
Split Lake
KELSEY
Nelson River
GILLAM
Hayes River
Gods Lake
Island Lake
ONTARIO
Sipiwesk Lake
WABOWDEN
Cross Lake
CROSS LAKE
JACK PORTAGE
Playgreen Lake
NORWAY HOUSE
WARREN LANDING
FLIN FLON
THE PAS
Moose Lake
Saskatchewan River
Cedar Lake
GRAND RAPIDS
LAKE WINNIPEG
POPLAR RIVER
BERENS RIVER
Berens River
Lake Winnipegosis
Lake Manitoba
GIMLI
SELKIRK
WINNIPEG
Winnipeg River
BRANDON
Assiniboine River
Red River
0 25 50 75 100
Scale in Miles
Jan 1973

---- Major Navigation Route
Ⓘ Docking Facility
▲ Warehousing
— - — M. S. Lord Selkirk



MAP VI

TRANSPORTATION AND NAVIGATION STUDY

LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS. STUDY BOARD

AIR TRANSPORTATION

RUNWAYS
▲ Asphalt
Gravel
△ Clay
Water
REGULARLY SCHEDULED COMMERCIAL ROUTES SERVING THE OUTLET LAKES:
Winnipeg - Berens River - Poplar River - Norway House - Cross Lake, etc.
Winnipeg - Norway House
Winnipeg - Norway House - Thompson
The Pas - Norway House
0
25
50
75
100
Scale in Miles
HUDSON
BAY
SASKATCHEWAN
ONTARIO
Churchill
Seal River
River
Reindeer Lake
Churchill
Southern Indian Lake
LYNN LAKE
SOUTH INDIAN LAKE
LEAF RAPIDS
River
Split Lake
Nelson
River
GILLAM
KELSEY
Churchill
NELSON HOUSE
THOMPSON
Burntwood
River
Hayes
River
SHAMATTAWA
Sipiwesk Lake
WABOWDEN
OXFORD HOUSE
FLIN FLON
Cross Lake
CROSS LAKE
Gods Lake
GODS LAKE
RED SUCKER LAKE
ISLAND LAKE
ST THERESA PT
Island Lake
Moose Lake
Playgreen Lake
NORWAY HOUSE
WARREN LANDING
THE PAS
Saskatchewan River
Cedar Lake
GRAND RAPIDS
LAKE
WINNIPEG
POPLAR RIVER
BERENS RIVER
Berens River
LITTLE GRAND RAPIDS
Lake Winnipegosis
Lake Manitoba
Assiniboine
BRANDON
River
WINNIPEG
Red River
Winnipeg

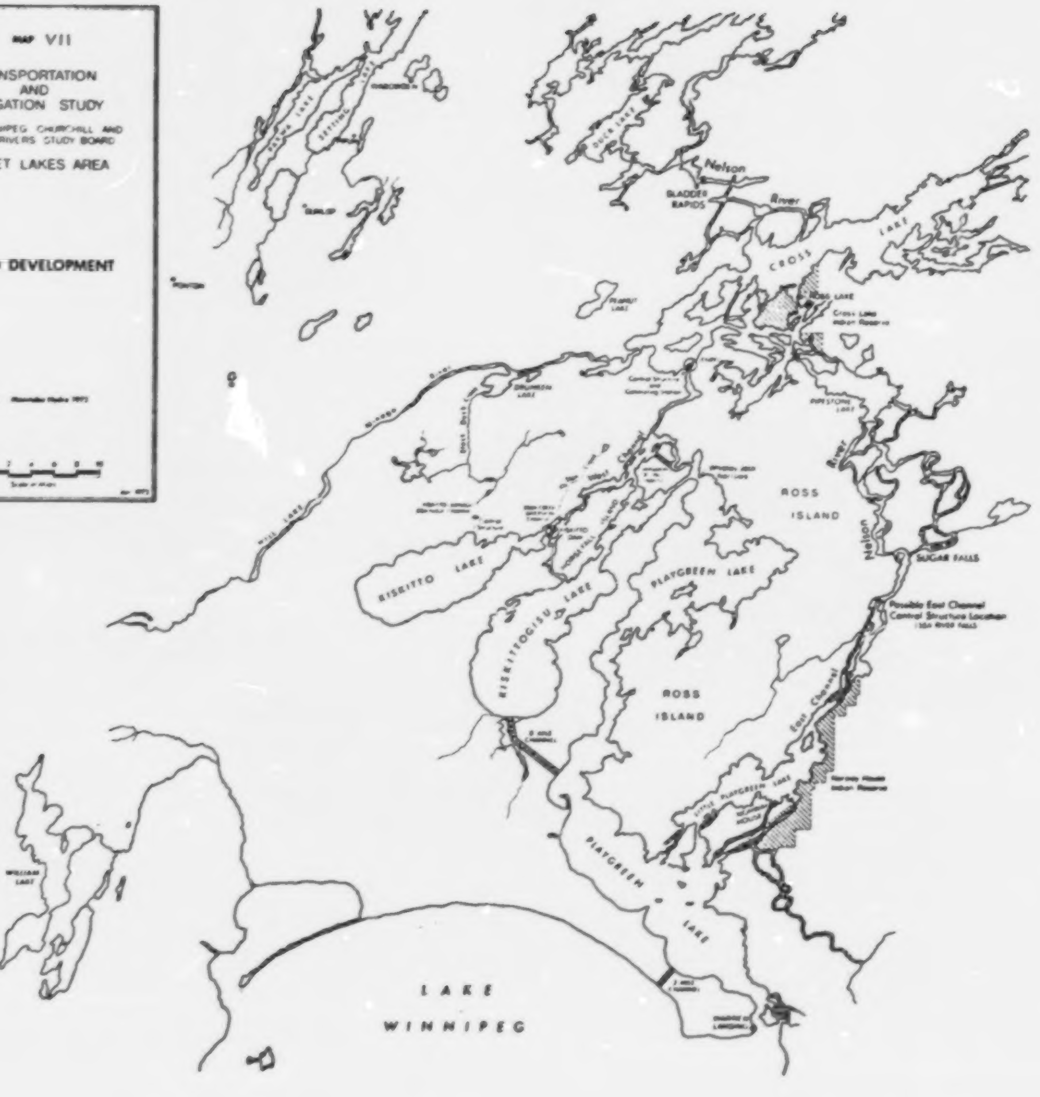
MAP VII

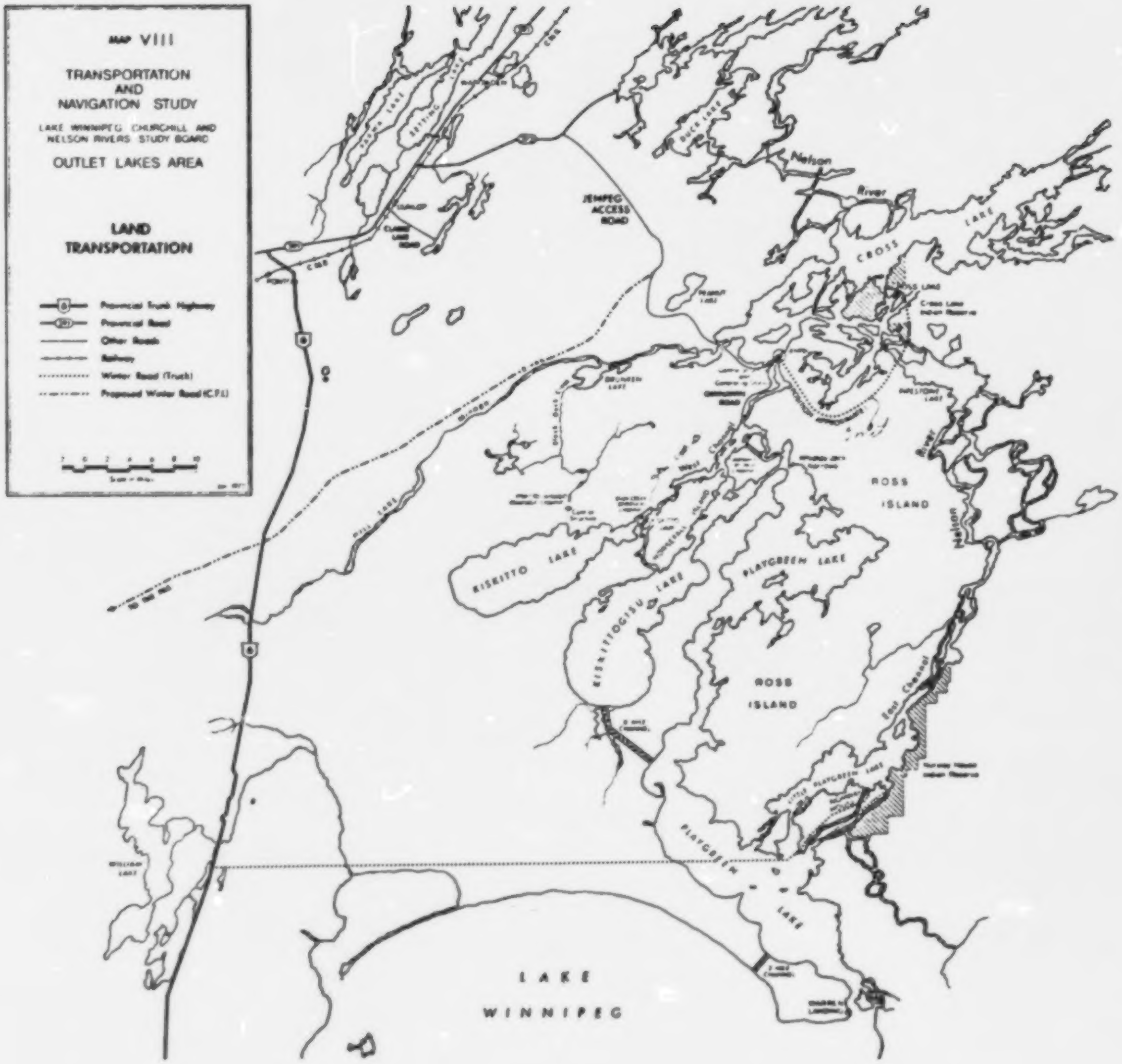
TRANSPORTATION AND NAVIGATION STUDY

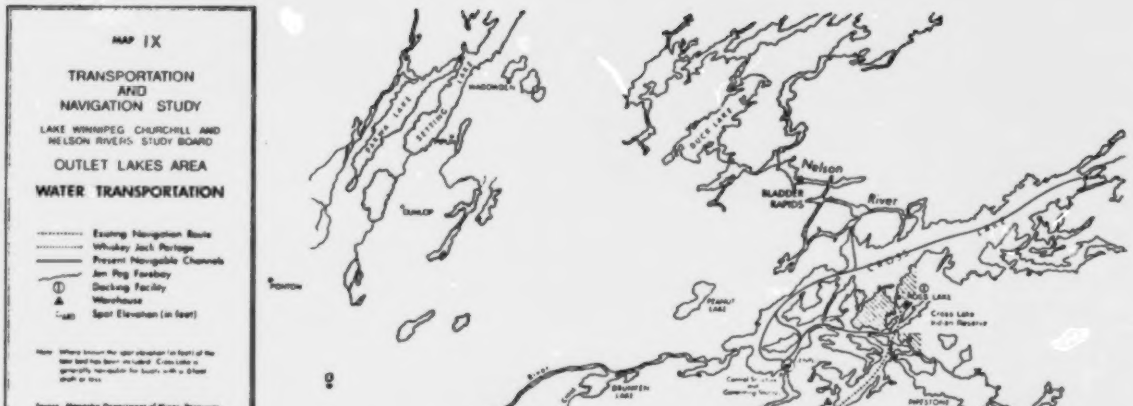
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

OUTLET LAKES AREA

HYDRO DEVELOPMENT


Nelson River
BLADDER RAPIDS
CROSS LAKE
Cross Lake Indian Reserve
PIPESTONE LAKE
ROSS ISLAND
Nelson River
SUGAR FALLS
Possible East Channel Control Structure Location
East Channel
KISKITTO LAKE
KISKITTOGISU LAKE
PLAYGREEN LAKE
ROSS ISLAND
LITTLE PLAYGREEN LAKE
Norway House Indian Reserve
PLAYGREEN LAKE
LAKE WINNIPEG
MINAGO RIVER
WILLIAM LAKE
Scale in Miles





MAP IX

TRANSPORTATION AND NAVIGATION STUDY

LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

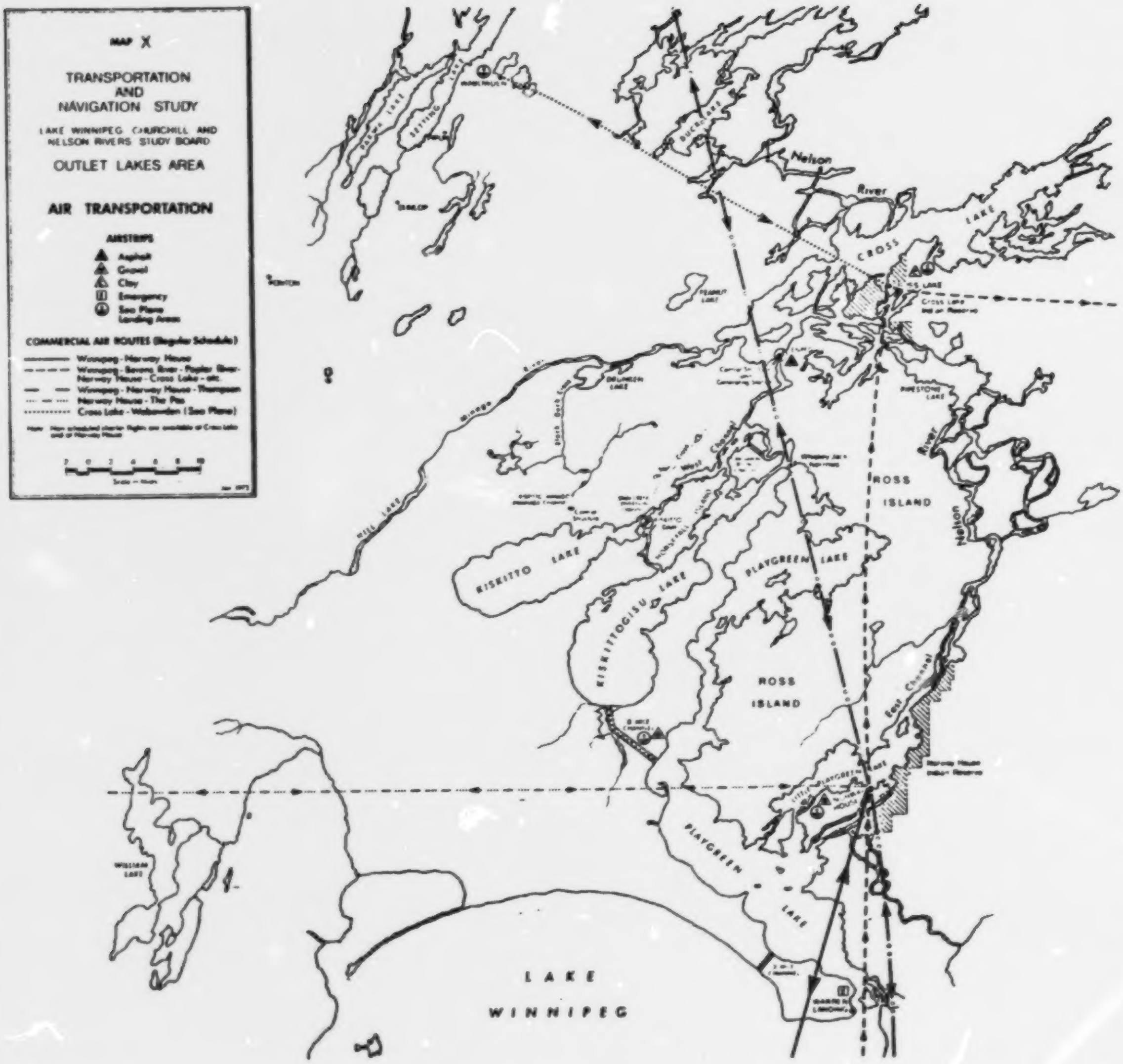
OUTLET LAKES AREA

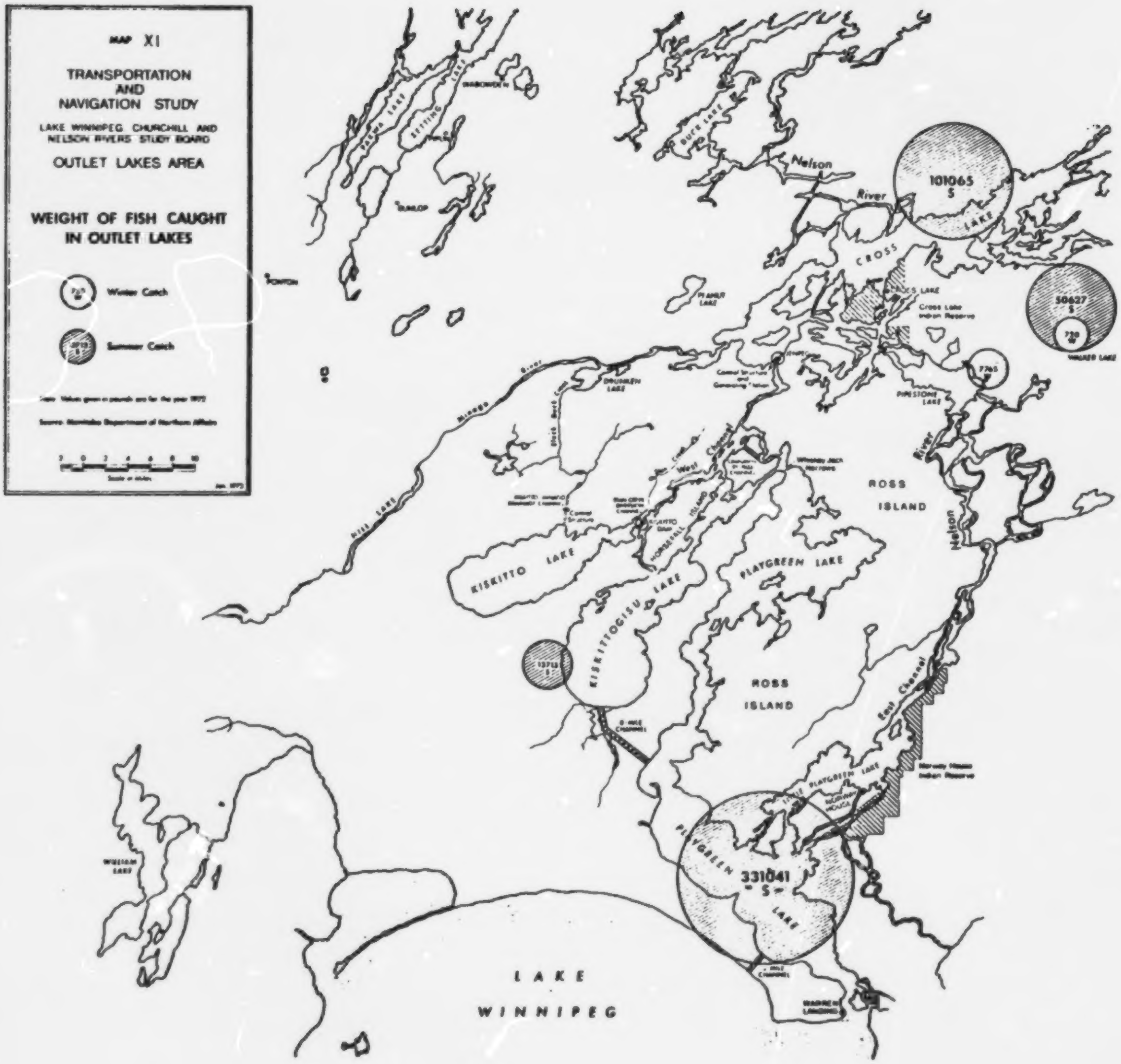
WATER TRANSPORTATION

Existing Navigation Route
Whiskey Jack Portage
Present Navigable Channels
Jen Peg Forebay
Docking Facility
Warehouse
Spot Elevation (in feet)
Nelson River
Bladder Rapids
Duck Lake
Setting Lake
Wabowden
Dunlop
Ponton
Cross Lake
Cross Lake Indian Reserve
Whiskey Jack Portage
Pipestone Lake
Drunken Lake
Minago River
Hill Lake
Ross Island
Playgreen Lake
Kiskitto Lake
Kiskittogisu Lake
8 Mile Channel
East Channel
Norway House Indian Reserve
Little Playgreen Lake
2 Mile Channel
Warren Landing
William Lake
Lake Winnipeg

Note: Where known the spot elevation (in feet) of the lake bed has been included. Cross Lake is generally navigable for boats with a 6 foot draft or less.

Source: Manitoba Department of Mines, Resources and Environmental Management and Canada Department of Public Works.


MAP X
TRANSPORTATION AND NAVIGATION STUDY
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD
OUTLET LAKES AREA
AIR TRANSPORTATION
AIRSTRIPS
Asphalt
Gravel
Clay
Emergency
Sea Plane Landing Areas
COMMERCIAL AIR ROUTES (Regular Schedule)
Winnipeg - Norway House
Winnipeg - Berens River - Poplar River - Norway House - Cross Lake - etc.
Winnipeg - Norway House - Thompson
Norway House - The Pas
Cross Lake - Wabowden (Sea Plane)
Scale — Miles
Nelson
River
CROSS
LAKE
PIPESTONE LAKE
ROSS ISLAND
Nelson River
KISKITTO LAKE
KISKITTOGISU LAKE
PLAYGREEN LAKE
ROSS ISLAND
East Channel
PLAYGREEN LAKE
LAKE WINNIPEG



MAP XI

TRANSPORTATION
AND
NAVIGATION STUDY

LAKE WINNIPEG, CHURCHILL AND
NELSON RIVERS STUDY BOARD

OUTLET LAKES AREA

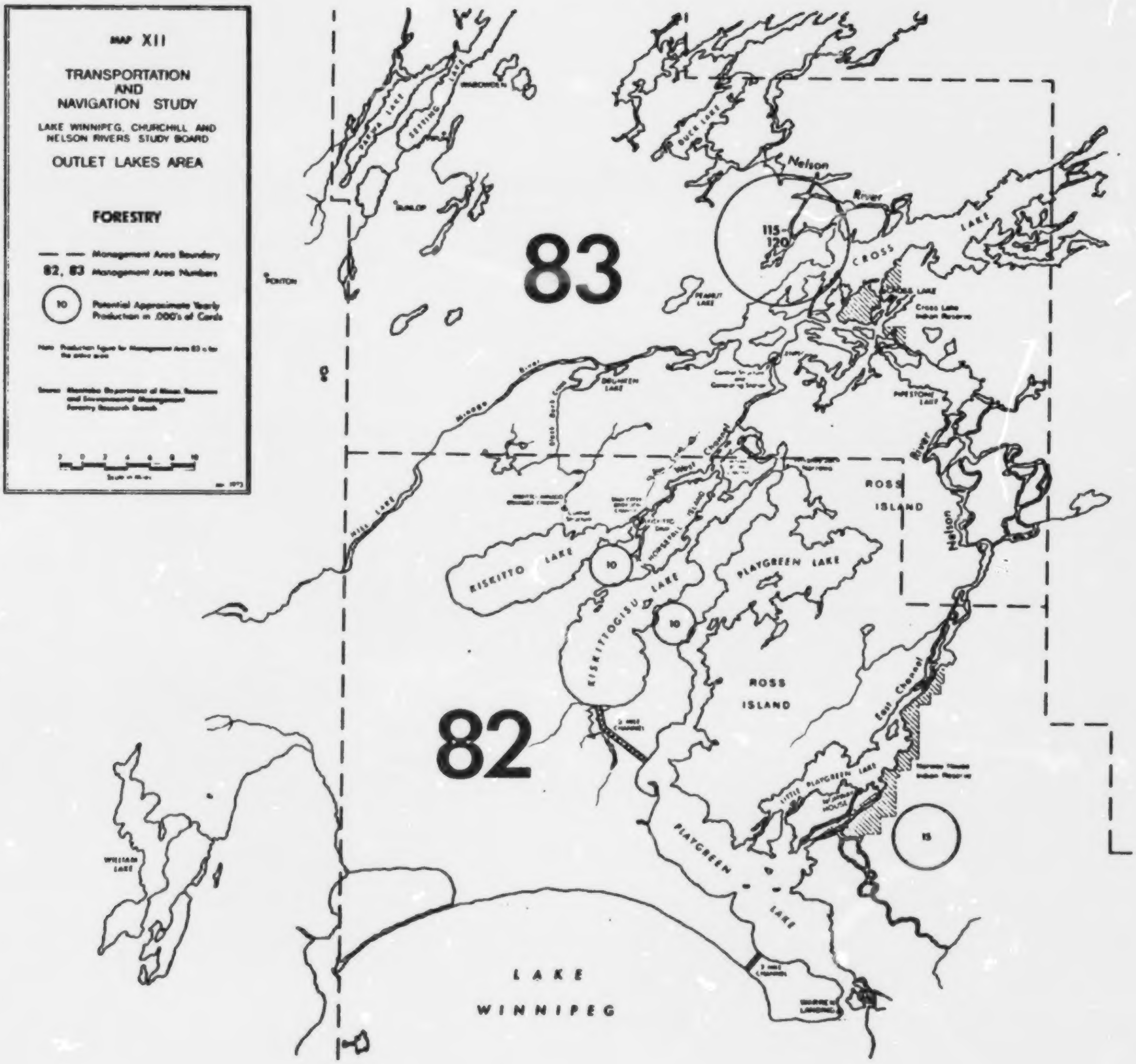
WEIGHT OF FISH CAUGHT
IN OUTLET LAKES

Note: Values given in pounds are for the year 1972

Source: Manitoba Department of Northern Affairs

Jan. 1973

Winter Catch
Summer Catch
Scale in Miles
2 0 2 4 6 8 10
SETTING LAKE
DUCK LAKE
Nelson River
101065 S
CROSS LAKE
Cross Lake Indian Reserve
50627 S
720 W
WALKER LAKE
7765 W
PIPESTONE LAKE
PEANUT LAKE
DRUNKEN LAKE
Minago River
Control Structure and Generating Station
West Channel
Whiskey Jack Narrows
ROSS ISLAND
Nelson River
KISKITTO LAKE
Control Structure
KISKITTO Dam
HORSEFALL ISLAND
PLAYGREEN LAKE
KISKITTOGISU LAKE
13713 S
2-MILE CHANNEL
ROSS ISLAND
East Channel
Norway House Indian Reserve
LITTLE PLAYGREEN LAKE
NORWAY HOUSE
PLAYGREEN LAKE
331041 S
WILLIAM LAKE
LAKE WINNIPEG
WARREN LANDING
PONTON



MAP XII

TRANSPORTATION
AND
NAVIGATION STUDY

LAKE WINNIPEG, CHURCHILL AND
NELSON RIVERS STUDY BOARD

OUTLET LAKES AREA

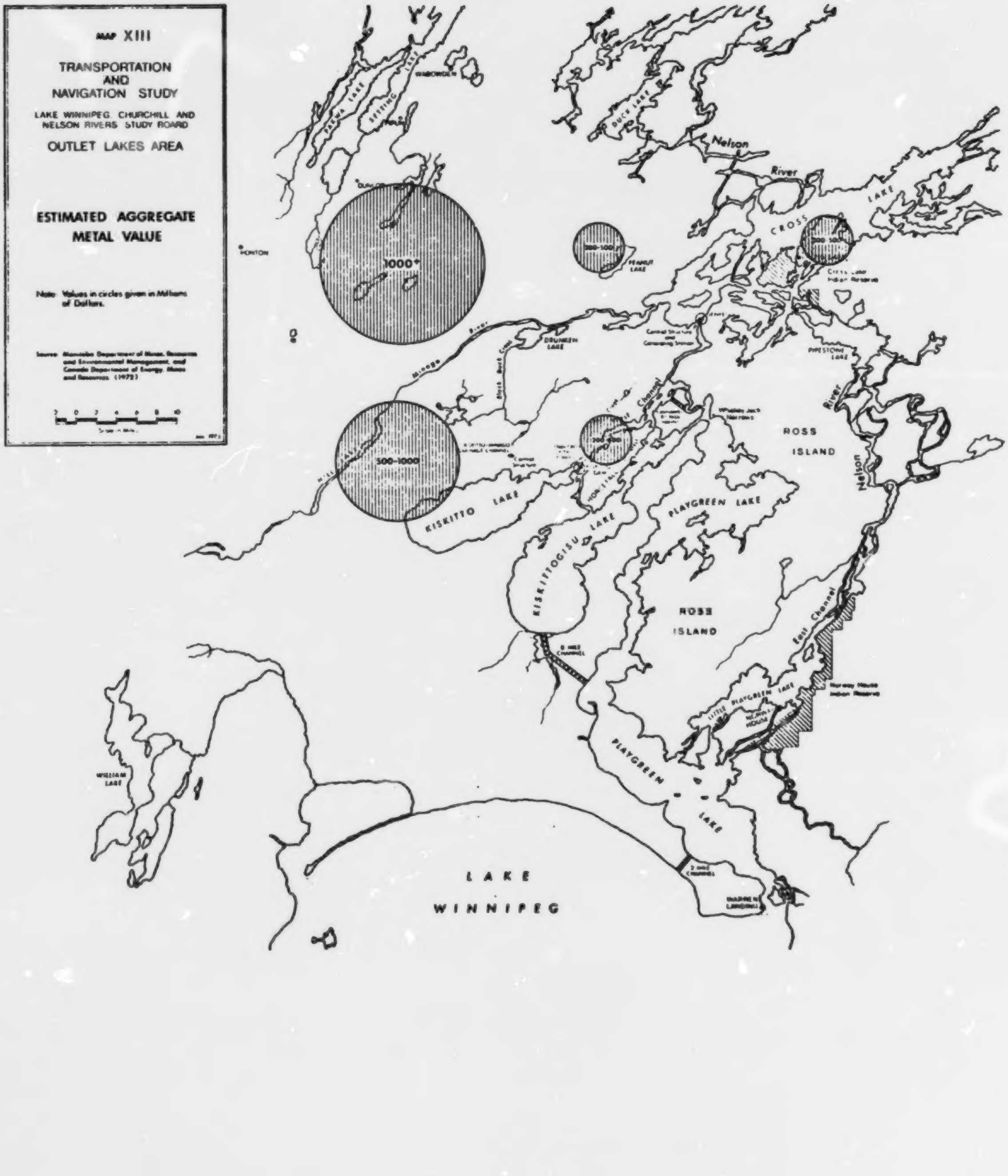
FORESTRY

Management Area Boundary
82, 83 Management Area Numbers
10 Potential Approximate Yearly Production in ,000's of Cords
2 0 2 4 6 8 10
Scale in Miles
83
82
115-120
10
10
15
Nelson River
Cross Lake
Cross Lake Indian Reserve
Duck Lake
Pearson Lake
Drunken Lake
Pipestone Lake
Minago River
Hill Lake
Setting Lake
Wabowden
Dunlop
Ponton
West Channel
Kiskitto Lake
Kiskittogisu Lake
Horsepoll Island
Playgreen Lake
Ross Island
Nelson River
East Channel
Little Playgreen Lake
Norway House
Norway House Indian Reserve
2 mile Channel
Warren Landing
William Lake
Lake Winnipeg

Note: Production figure for Management Area 83 is for the entire area

Source: Manitoba Department of Mines, Resources and Environmental Management
Forestry Research Branch

1973


MAP XIII

TRANSPORTATION
AND
NAVIGATION STUDY

LAKE WINNIPEG, CHURCHILL AND
NELSON RIVERS STUDY BOARD

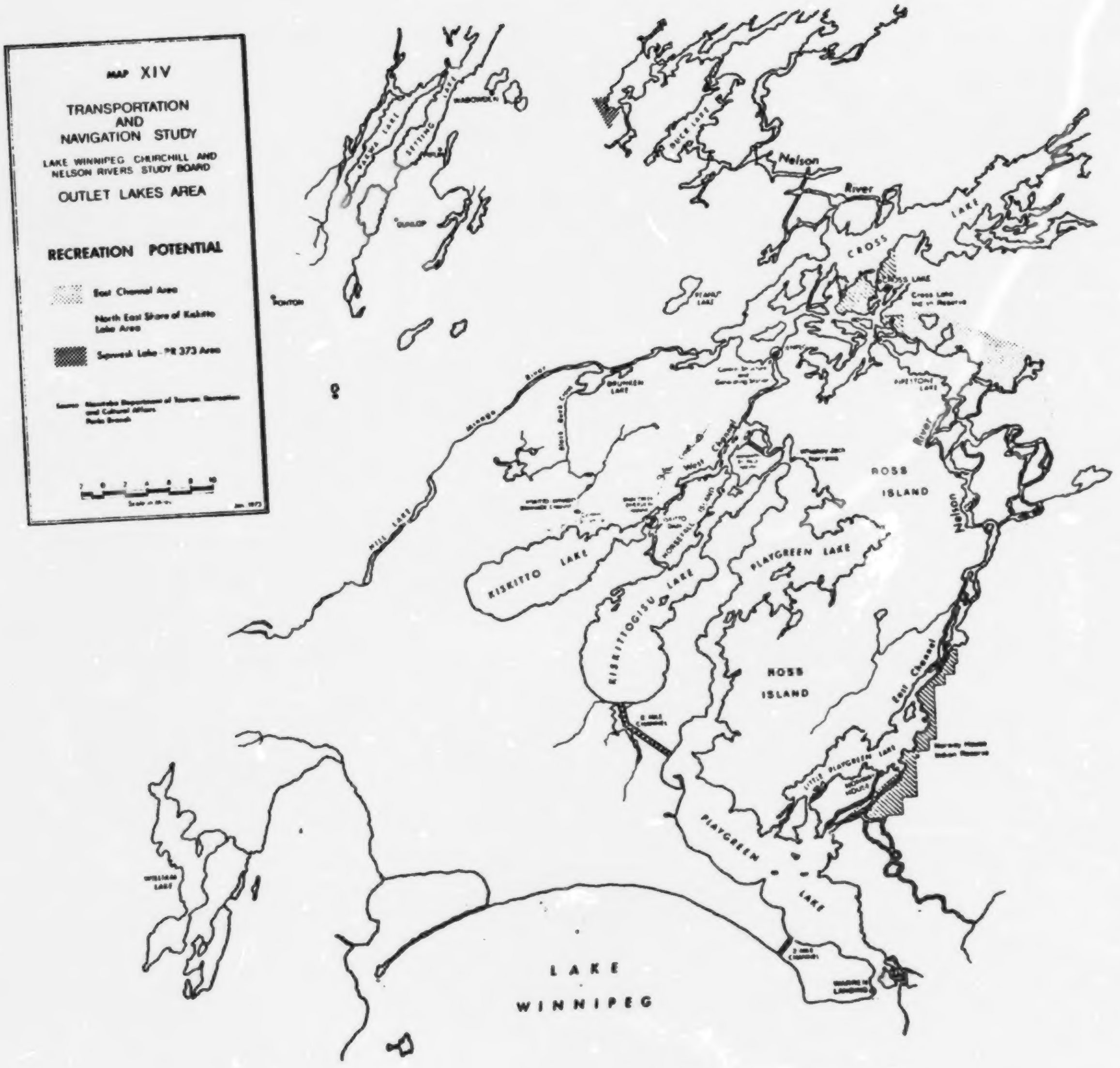
OUTLET LAKES AREA

**ESTIMATED AGGREGATE
METAL VALUE**

Note: Values in circles given in Millions of Dollars.

Source: Manitoba Department of Mines, Resources and Environmental Management, and Canada Department of Energy, Mines and Resources (1972)

0 2 4 6 8 10
Scale in Miles
SETTING LAKE
WABOWDEN
DUCK LAKE
Nelson
River
CROSS LAKE
1000+
300-500
PEANUT LAKE
PONTON
Cross Lake Indian Reserve
DRUNKEN LAKE
Minago River
Black Duck Creek
Control Structure and Generating Station
PIPESTONE LAKE
Channel
Whiskey Jack Narrows
ROSS ISLAND
500-1000
200-500
KISKITTO LAKE
KISKITTOGISU LAKE
PLAYGREEN LAKE
ROSS ISLAND
8 MILE CHANNEL
East Channel
Nelson River
Norway House Indian Reserve
LITTLE PLAYGREEN LAKE
NORWAY HOUSE
WILLIAM LAKE
PLAYGREEN LAKE
2 MILE CHANNEL
WARREN LANDING
LAKE WINNIPEG



MAP XIV

TRANSPORTATION
AND
NAVIGATION STUDY

LAKE WINNIPEG CHURCHILL AND
NELSON RIVERS STUDY BOARD

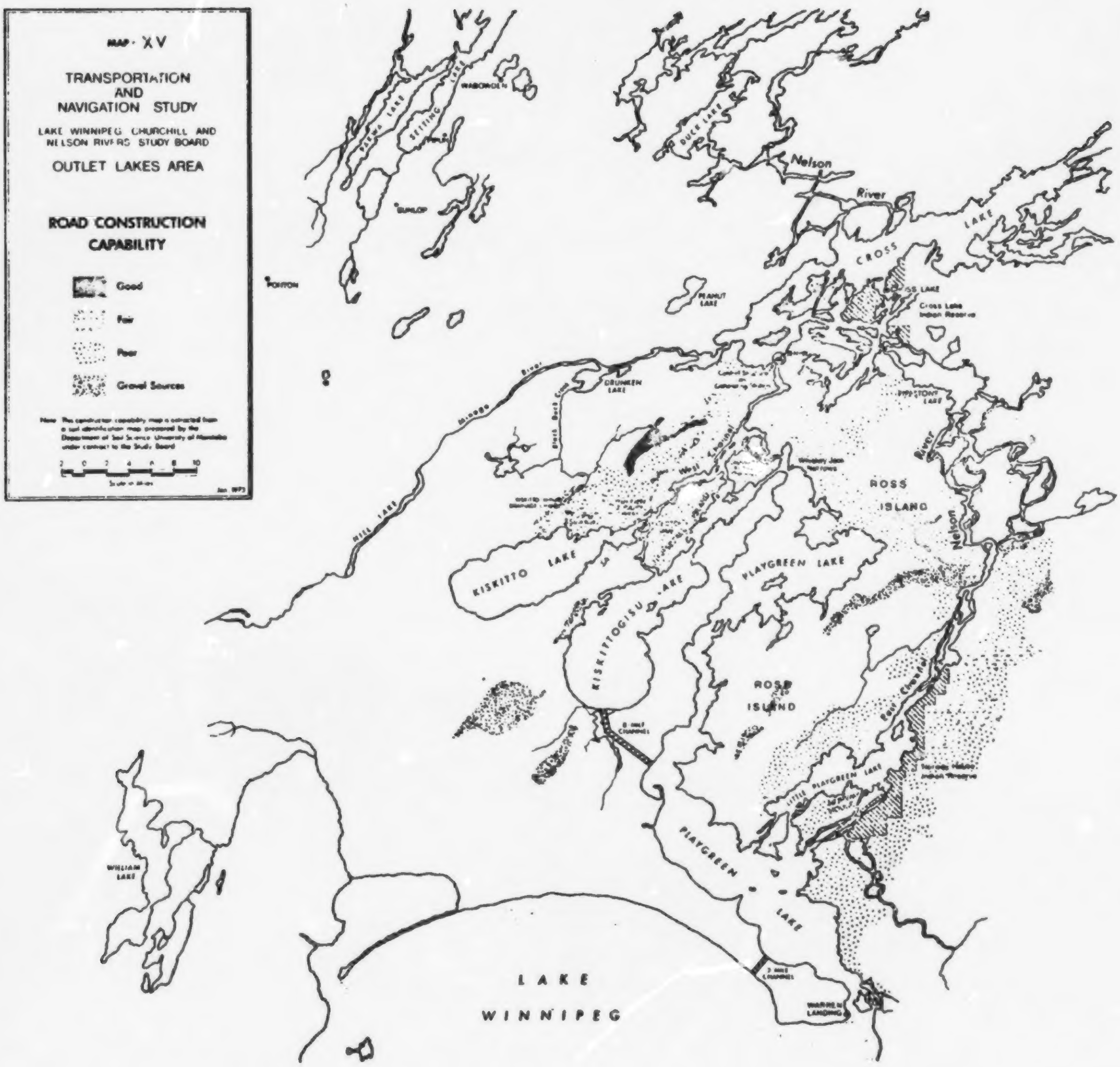
OUTLET LAKES AREA

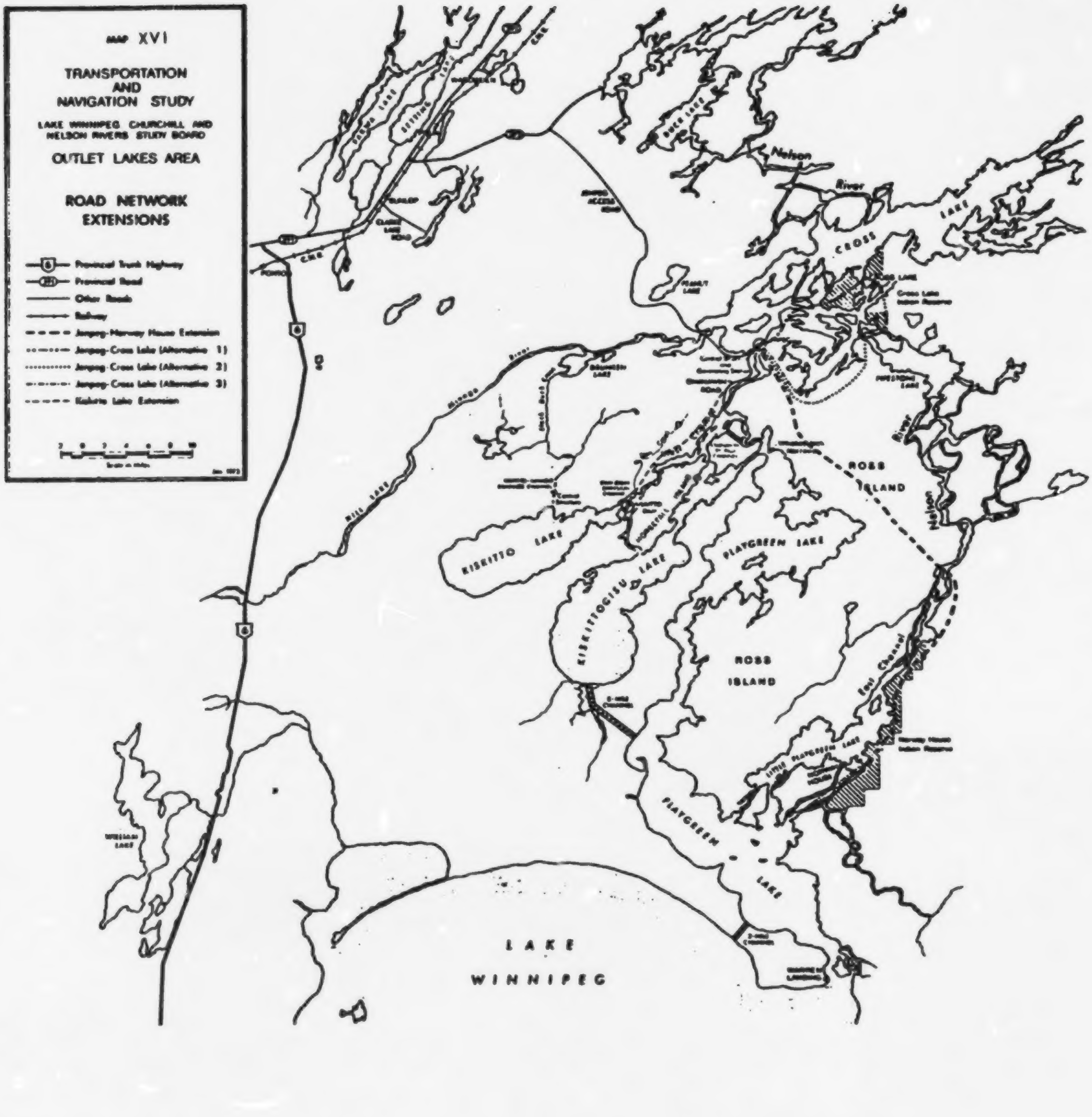
RECREATION POTENTIAL

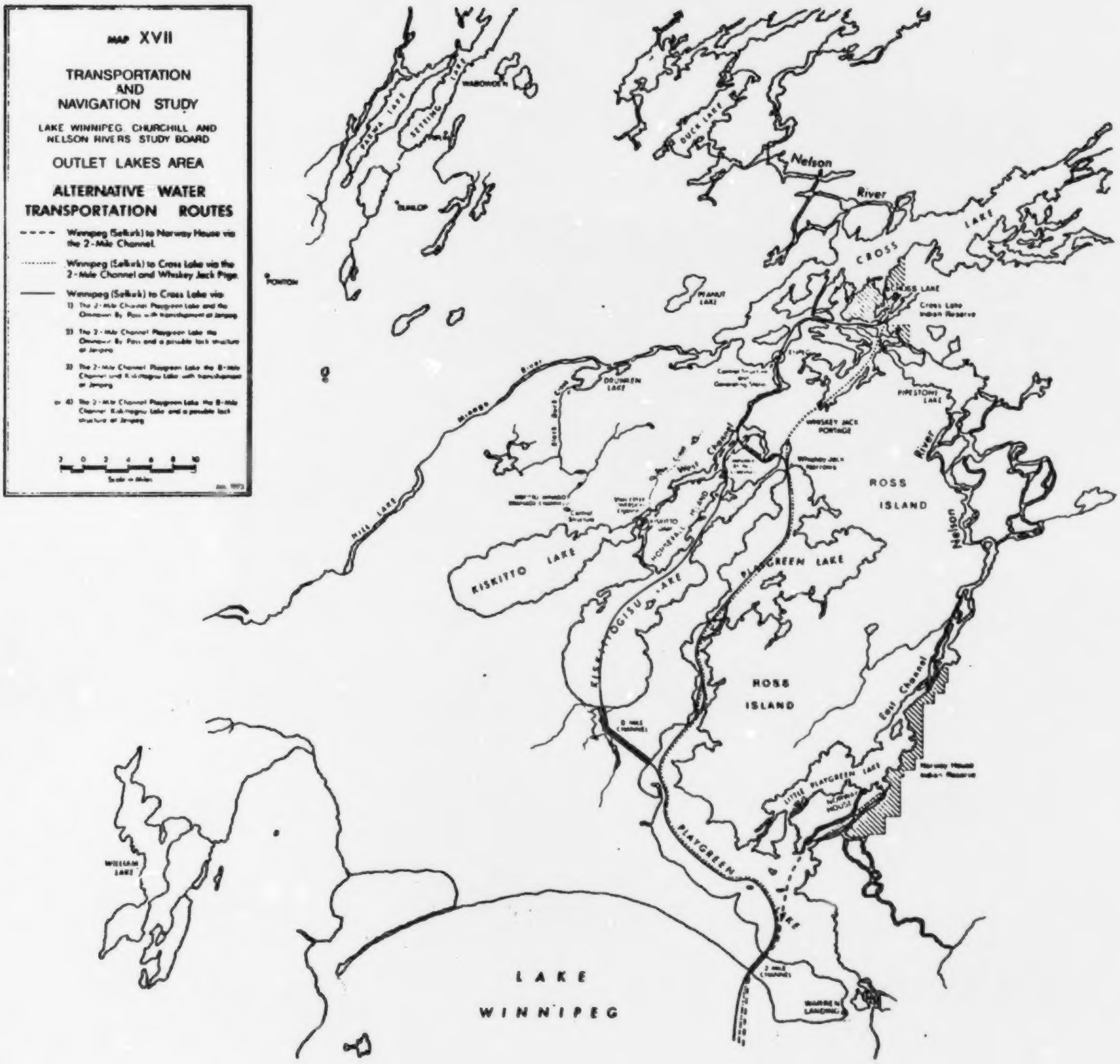
East Channel Area
North East Shore of Kiskitto Lake Area
Sipiwesk Lake - PR 373 Area
Scale in Miles
0
2
4
6
8
10
PAKWA LAKE
SETTING LAKE
WABOWDEN
DUNLOP
PONTON
DUCK LAKE
Nelson
River
CROSS
LAKE
CROSS LAKE
Cross Lake Indian Reserve
PEARSON LAKE
PIPESTONE LAKE
Minago River
DRUNKEN LAKE
West Channel
ROSS
ISLAND
Nelson
River
HILL LAKE
KISKITTO LAKE
HORSEFALL ISLAND
KISKITTOGISU LAKE
PLAYGREEN LAKE
ROSS
ISLAND
East Channel
Norway House Indian Reserve
LITTLE PLAYGREEN LAKE
NORWAY HOUSE
8 MILE CHANNEL
PLAYGREEN
LAKE
2 MILE CHANNEL
WARREN LANDING
WILLIAM LAKE
LAKE
WINNIPEG

Source: Manitoba Department of Tourism, Recreation and Cultural Affairs, Parks Branch

Jan. 1973

MAP - XV
TRANSPORTATION AND NAVIGATION STUDY
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD
OUTLET LAKES AREA
ROAD CONSTRUCTION CAPABILITY
Good
Fair
Poor
Gravel Sources
Note: The construction capability map is extracted from a soil identification map prepared by the Department of Soil Science, University of Manitoba under contract to the Study Board
2 0 2 4 6 8 10
Scale in Miles
Jan. 1973
SETTING LAKE
WABOWDEN
PONTON
DUCK LAKE
Nelson
River
CROSS LAKE
PEANUT LAKE
Cross Lake Indian Reserve
DRUNKEN LAKE
Minago River
PIPESTONE LAKE
Whiskey Jack Narrows
ROSS ISLAND
Nelson River
KISKITTO LAKE
KISKITTOGISU LAKE
PLAYGREEN LAKE
ROSS ISLAND
East Channel
Norway House Indian Reserve
LITTLE PLAYGREEN LAKE
8 MILE CHANNEL
WILLIAM LAKE
PLAYGREEN LAKE
2 MILE CHANNEL
WARREN LANDING
LAKE WINNIPEG


MAP XVI
TRANSPORTATION AND NAVIGATION STUDY
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD
OUTLET LAKES AREA
ROAD NETWORK EXTENSIONS
6 Provincial Trunk Highway
373 Provincial Road
Other Roads
Railway
Jenpeg-Norway House Extension
Jenpeg-Cross Lake (Alternative 1)
Jenpeg-Cross Lake (Alternative 2)
Jenpeg-Cross Lake (Alternative 3)
Kiskitto Lake Extension
Scale in Miles
CROSS
LAKE
Nelson
River
Cross Lake Indian Reserve
ROSS
ISLAND
Nelson
River
KISKITTO LAKE
KISKITTOGISU LAKE
PLAYGREEN LAKE
ROSS
ISLAND
East Channel
Norway House Indian Reserve
LITTLE PLAYGREEN LAKE
PLAYGREEN
LAKE
LAKE
WINNIPEG
Minago River
CNR
6
6
6
373
SETTING LAKE
JENPEG ACCESS ROAD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TRANSPORTATION AND NAVIGATION STUDY
LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD
OUTLET LAKES AREA
ALTERNATIVE WATER TRANSPORTATION ROUTES
Winnipeg (Selkirk) to Norway House via the 2-Mile Channel.
Winnipeg (Selkirk) to Cross Lake via the 2-Mile Channel and Whiskey Jack Ptge.
Winnipeg (Selkirk) to Cross Lake via:
1) The 2-Mile Channel Playgreen Lake and the Ominawin By Pass with transhipment at Jenpeg
2) The 2-Mile Channel Playgreen Lake the Ominawin By Pass and a possible lock structure at Jenpeg
3) The 2-Mile Channel Playgreen Lake the 8-Mile Channel and Kiskittogisu Lake with transhipment at Jenpeg
or 4) The 2-Mile Channel Playgreen Lake the 8-Mile Channel Kiskittogisu Lake and a possible lock structure at Jenpeg
2 0 2 4 6 8 10
Scale in Miles
Jan. 1973
SIPIWESK LAKE
SETTING LAKE
WABOWDEN
DUNLOP
PONTON
DUCK LAKE
Nelson River
CROSS LAKE
PEANUT LAKE
CROSS LAKE
Cross Lake Indian Reserve
DRUNKEN LAKE
Minago River
Dock Duck Cr.
HILL LAKE
Control Structure and Generating Station
PIPESTONE LAKE
WHISKEY JACK PORTAGE
Whiskey Jack Narrows
West Channel
Control Structure
ROSS ISLAND
Nelson River
KISKITTO LAKE
MONTEAGLE ISLAND
PLAYGREEN LAKE
KISKITTOGISU LAKE
8 MILE CHANNEL
ROSS ISLAND
East Channel
Norway House Indian Reserve
LITTLE PLAYGREEN LAKE
NORWAY HOUSE
WILLIAM LAKE
PLAYGREEN LAKE
2 MILE CHANNEL
WARREN LANDING
LAKE WINNIPEG

APPENDIX 4 - N

SOUTHERN INDIAN LAKE -
RAT-BURNTWOOD DIVERSION -
TRANSPORTATION AND NAVIGATION STUDY
(PART ONE)

SOUTHERN INDIAN LAKE - RAT-BURNTWOOD DIVERSION
TRANSPORTATION AND NAVIGATION STUDY
PART ONE

by

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Winnipeg, Manitoba
October, 1973

for

THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SPECIAL NOTE

THE CONCLUSIONS AND RECOMMENDATIONS CONTAINED IN THIS APPENDIX ARE THOSE OF THE AUTHOR(S) AND ARE NOT NECESSARILY THE SAME AS THE CONCLUSIONS AND RECOMMENDATIONS OF THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD AS EXPRESSED IN THE SUMMARY REPORT AND THE TECHNICAL REPORT.

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Mr. K. Weagle, Resource Management Branch, Environment Canada

2. Provincial Government Agencies

Research and Planning Branch, Manitoba Department of Northern Affairs

Manitoba Department of Highways

Leaf Rapids Corporation

3. Others

Mr. Mac Riddell, Local Government District Administrator, Local Government District of Leaf Rapids

Mr. George Scott, Acting Manager, South Indian Lake branch of Hudson's Bay Company

ABSTRACT

As a result of priorities established by the Study Board, the present report forms the first part of a two part study into the effects of Hydro development on transportation and navigation in the Southern Indian Lake - Rat-Burntwood Diversion study area.

Included in Section II of this report is a description of the approach to be used in examining the ramifications of Hydro development on the physical transportation infrastructure in the above study area as well as a specific analysis of the effects on the infrastructure in the Southern Indian Lake region of the study area.

Section III of the report outlines the method of approach to be used (in part two of the study due March 31, 1974) in the analysis of the consequences of Hydro development on the service aspect of transportation in the Southern Indian Lake - Rat-Burntwood Diversion study area.

I OBJECTIVES AND TERMS OF REFERENCE

As a component of the overall study undertaken by the Lake Winnipeg, Churchill and Nelson Rivers Study Board this report contains the results of the first of a two part investigation (the second part to be submitted March 31, 1974) into the implications of the Churchill River Diversion hydro-electric development program for existing and proposed transportation and navigation facilities and services in the Southern Indian Lake - Rat-Burntwood Diversion Study area.

This report consists of two sections. Section II describes the approach to be used in examining the ramifications of Hydro development (the Churchill River Diversion) on the physical transportation infrastructure in the Southern Indian Lake - Rat-Burntwood study area. This section also includes a specific analysis of the effects of Hydro development on the infrastructure related to the Southern Indian Lake portion of the study area. An examination of the effects on infrastructure in the Rat-Burntwood portion of the study area will be undertaken in the final report, part two of the investigation (due March 31, 1974).

Section III of this report outlines the methodology to be used (in the final report) in analyzing the effects of Hydro development on transportation services in the Southern Indian Lake - Rat-Burntwood study area. Included under "services" will be both resource product removal (forest products, fish, etc.) and importation of commodities to the communities concerned for both industrial and consumer use. As an aid to understanding the transportation services analysis procedure adopted, a demonstrative example of this procedure will also be included in this section.

As indicated, and resulting from priorities established by the Study Board, the terms of reference of this study envision a two part approach. Part one, the present report as described above, is due October 1, 1973. Part two will consist of an examination of the effects of Hydro development on transportation infrastructure in the Rat-Burntwood portion of the study area as well as an analysis of the effects of Hydro development on the transportation services in the entire study area (using the methodology outlined in this report) and is due March 31, 1974.

II. TRANSPORTATION INFRASTRUCTURE ANALYSIS

A. Introduction

Although the transportation infrastructure in the Southern Indian Lake - Rat-Burntwood Study area is not extensive, any detrimental effects to this infrastructure as a result of Hydro development could have far reaching ramifications in terms of disruption of person travel patterns, product removal methods and/or commodity importation procedures. It is most important, therefore, to examine this infrastructure and identify any portions which may be altered as a consequence of Manitoba Hydro's diversion of the Churchill River.

B. Method of Approach

The approach to be taken in examining the effects on the transportation infrastructure will be common to both the Southern Indian Lake and Rat-Burntwood regions of the study area. This section of the report outlines the method of approach to be used for both regions and also specifically examines the Southern Indian Lake transportation infrastructure. The report due March 31, 1974 will examine the effects to the infrastructure in the Rat-Burntwood region.

The infrastructure will first be divided into various components such as docks, all weather roads, airstrips etc. and each component will be fully described. The effect of Hydro development on each infrastructure component is then assessed in terms of both direct and indirect consequence to the area concerned. Finally, any remedial action deemed necessary as a result of Hydro development effects is identified in terms of the type and cost (where possible) of this action.

C. Southern Indian Lake Region Infrastructure

This section of the report examines the effects of Hydro development on the transportation infrastructure in the Southern Indian Lake portion of the study area. For the purposes of this examination the infrastructure will be categorized in the following manner: all-weather roads, intr-community roads, winter roads, navigation, docks and wharves, sea plane landing bases and airstrips.

1. All-Weather Roads[1]

a) Description

There is basically one general type of all-weather road in this portion of the study area; the classification of this type of road, according to the Manitoba Department of Highways is as "Other Roads." These roads are characterized by the fact that they are constructed to provide access to specific areas of activity such as mine sites, hydro sites, etc.

In the Southern Indian Lake portion of the study area, two connecting sections of road have been identified which are included in this category (see Map I).

The first section of this road has been built from Leaf Rapids to Ruttan Lake by the Department of Highways to serve the Sherritt-Gordon mine site north of the Lake. An extension of this road is presently being constructed by the Highways Department to the southern end of Sovith Bay on Southern Indian Lake. This road is scheduled to be completed by September 15, 1973[1] and is to provide access to the Manitoba Hydro diversion channel construction site as well as to possibly provide the initial link in a barge operation to supply the Missi Falls control structure site.

---

[1] Information for this section was provided by Manitoba Hydro and Manitoba Department of Highways.

b) Hydro Development Effects

As a result of the construction of the control structures at Missi Falls and Notigi Lake as well as the creation of a man-made channel linking South Bay with Issett Lake (and the Rat-Burntwood River System) Southern Indian Lake and the waters upstream of the Notigi control structure will be raised gradually to an elevation of 847 feet, with a maximum permissible level of 850 feet. During operation as a reservoir, the maximum fluctuation permitted on Southern Indian Lake in any twelve month period will be two feet.[2]

The portion of road from Leaf Rapids to Ruttan Lake mine site is of sufficient elevation and far enough distant from the reservoir which will be created upstream of the Notigi control structure so as to be unaffected by the higher water levels.

With regard to the remaining portion of road from Ruttan Lake to South Bay, according to the Manitoba Department of Highways "The alignment of the access road is generally good and it is presently being constructed so that it will not be flooded when the Hydro development at South Bay is complete."[3] Therefore road access to South Bay from Leaf Rapids and PR391 will remain unimpaired post regulation.

---

[1] Letter to the authors from Manitoba Department of Highways, August 14, 1973.

[2] Manitoba Hydro News Release, January 25, 1973.

[3] Letter to authors from Manitoba Department of Highways, August 14, 1973.

A direct effect of this continuing road access from PR391 to South Bay post regulation is the possibility of it forming the initial link in a future all-weather road to South Indian Lake community, due to the fact that the terminus of this road will be approximately ten miles from the community.

2. Intra-Community Roads[1]

a) Description

The community of South Indian Lake is currently undergoing an extensive development program which, when completed, will see the relocation of the present shopping and nursing facilities from their present location on the west shore of the "Narrows" portion of Southern Indian Lake to the east shore. Also to be included in the same "town center" complex will be a new school, gymnasium, skating rink and other amenities. This relocation and development of the east shore of the community will also include new housing sites for the residents with corresponding road linkage to both the town center and the airstrip. The present plans call for the construction of roads which will be more pedestrian-oriented than vehicle-oriented, due to the lack of vehicles in the community and the lack of road access to the rest of the province.

b) Hydro Development Effects

The above mentioned roads will be constructed, for the most part, at an elevation above 860 feet. Therefore it is highly unlikely that they will suffer any adverse effects due to Hydro development.

---

[1] Much of the information in this section was provided by the Research and Planning Branch, Department of Northern Affairs.

3. Winter Roads

a) Description

Only two winter roads will be in existence in the Southern Indian Lake area in the winter of 1973-74. With the completion of the South Bay all-weather road (see C-1) by the fall of 1973, the South Bay - South Indian Lake section will be all that remains of the winter road which previously ran from Ruttan Lake to South Indian Lake community via South Bay (see Map I). The second winter road in this area will be from South Bay to Missi Falls, to provide access overland to the Missi Falls control structure construction site (see Map I).

b) Hydro Development Effects

i) South Bay - South Indian Lake Winter Road: This road crosses the ice of South Bay and as such could be affected by any changes in the ice regime on South Bay and in the vicinity of South Indian Lake community. Small patches of open water are likely to remain year round in the Narrows immediately opposite the site of the new South Indian Lake town center;[1] thus the ice in the immediate vicinity of this open water may not be thick enough to withstand the heavy trucks which travel on the winter road. The ice situation post regulation on South Bay itself is unavailable at this time and therefore no comment can be made as to the effects on the South Bay portion of the winter road.

ii) South Bay - Missi Falls Winter Road: This road initially crosses portions of South Bay and as such may be affected by changes in the ice regime as a result of regulation. As indicated previously, detailed information on the nature of these changes is unavailable at this time. The largest portion of the South Bay-Missi Falls winter road, however, is overland, and as such should be unaffected by ice conditions on Southern Indian Lake, post regulation.

---

[1] Taken from information provided to Manitoba Department of Northern Affairs by Manitoba Hydro Hydraulic Design Department.

c) Remedial Action

i) South Bay - South Indian Lake Winter Road: Since the area in the immediate vicinity of the community of South Indian Lake will contain patches of open water in winter, possibly affecting the strength of the ice cover, it is imperative that some form of remedial action take place. One possibility could be the strengthening of the ice cover by artificially building up the ice over a period of time to a certain width and thickness which would permit heavy trucks to use the road. Another possibility would be the extensive use of ice bridges (timbers frozen in open water) to cross open stretches of water. Alternatively, the winter road could be diverted to an over land route before it encounters the thin ice in the vicinity of South Indian Lake community.

ii) South Bay - South Indian Lake and South Bay - Missi Falls Winter Roads: Both of these winter roads cross the ice on South Bay and as such could be affected by changes in the ice regime on South Bay due to regulation. As mentioned previously, detailed information is unavailable as to the type of changes which may take place regarding the ice cover, once the diversion scheme is operational. Such information should be made available in order to judge the future viability of the winter roads which presently cross the ice of South Bay, particularly in the case of the South Bay - South Indian Lake winter road which uses the over-the-ice route exclusively.

4. Navigation

a) Description

Apart from use of small motor boats and canoes on other waterways, navigation in the Southern Indian Lake region is confined to the lake itself. Southern Indian Lake is navigable throughout most of its surface area. At present the most frequently travelled routes (see Map I) are from Leaf Rapids to South Indian Lake community (used primarily by fishermen) and South Bay to Missi Falls (used to supply the Hydro construction site). The most hazardous stretch of water on the former navigation route is from Leaf Rapids to Opachuanau Lake. This is due to stretches of rapids and shallow depth in places (the water level elevation changes from approximately 850 feet at Leaf Rapids to approximately 836 feet on Opachuanau Lake[1]). Other than this area, the navigation routes are basically hazard free.

The extent of the season for navigation on Southern Indian Lake is from approximately the first week of June to the last week of October. Local lake conditions may influence the dates of exact opening and closing of the season.

b) Hydro Development Effects

As discussed in C-1 (b), Hydro development will raise the level of Southern Indian Lake to a maximum elevation of 850 feet. In effect, this will eliminate the approximate 14 foot drop in water level from Leaf Rapids to Opachuanau Lake discussed earlier. Such an occurrence, depending on the type of vessel which will be used and the present depth of the navigable channel, could improve the navigability of this stretch of water. Conversely, the increased water levels on Southern Indian Lake post regulation will result in the total or partial inundation of many tiny islands (creating reefs and shallows) along both major navigation routes. This may affect area residents who are now familiar with navigable routes and who may be required to relearn these routes due to the formation of new shallows and reefs and the submergence of old reefs after the diversion has taken place.

---

[1] Taken from elevations on the Surveys and Mapping Branch map of Manitoba.

c) Remedial Action

The possible creation of new hazards to navigation (such as partially submerged islands etc.) discussed above and the subsequent process of learning new routes which could result after the Churchill River diversion is completed may require remedial action. Several courses of action are possible. A primary requisite would be the identification of islands along the present navigation routes which could be fully or partially inundated post regulation. Each island so affected could be permanently marked in a manner (buoys, lights, etc.) which would identify the particular hazard (reef, shallows, etc.) after the diversion is completed. This process should commence before the flooding takes place. A charting of the best post regulation navigable route from Leaf Rapids to South Indian Lake could also be undertaken to indicate the extent to which navigation will be improved along the Leaf Rapids-Opachuanau Lake portion of this route and also as an aid to navigation along the entire course of the route.

5. Docks and Wharves

a) Description

The Southern Indian Lake region contains several major marine facilities as well as numerous smaller private docks. The major facilities include docks at South Indian Lake, South Bay (at the terminus of the Ruttan Lake - South Bay road) and Missi Falls. There are also a number of smaller docking facilities associated with the various fish camps on Southern Indian Lake. A listing of these fish camp docks including the length and approximate elevation is given in Table 1.

The docking facilities at South Indian Lake community are to undergo reconstruction as a part of the development program mentioned earlier in this report. A main dock along with several secondary docks are to be built. The main dock will also serve as a berthing area for sea planes. All of these new facilities will be constructed at an elevation well above 850 feet.[1]

Very little detailed information regarding length and elevation of the docking facilities at South Bay and Missi Falls is available at this time. However, since both facilities are to be used by Manitoba Hydro and its contractors in transporting construction materials to Missi Falls by barge, it is assumed that they have been built with the diversion in mind.

b) Hydro Development Effects

i) Major Facilities (see Map I): The new docking facilities at South Indian Lake community are to be built at an elevation well above 850 feet, as mentioned above. As such they should be unaffected by Hydro development.

---

[1] Information source: Research and Planning Branch, Manitoba Department of Northern Affairs.

Table 1[1]

DOCKS ASSOCIATED WITH FISH CAMPS ON S.I.L.

CAMP	LENGTH OF DOCK	ELEV
Number 1	130 Feet	842
Number 2	10 Feet	846
Number 5	125 Feet	841
Number 7	100 Feet (Damaged)	840
Number 9	30 Feet	841
Number 10	60 Feet	839
Number 11	20 Feet	840
Number 12	35 Feet	844
Number 13	50 Feet	839
Number 14	40 Feet	839
Number 15	60 Feet	846
Number 16	40 Feet	839
Number 16-B	25 Feet	839
Number 27	50 Feet	847

---

[1] Taken from "Real Property Assessment - Southern Indian Lake - Rat-Burntwood Diversion Route", Preliminary Report prepared by Planning Division, Water Resources Branch.

The Hydro docks at South Bay and Missi Falls will be in use until the diversion scheme is completed and may also be used post regulation to supply Missi Falls. If the latter is not the case, these docks may be abandoned or removed after regulation. No information is available as to the elevation of these facilities, however, and therefore no comment will be made as to Hydro development effects.

ii) Fish Camp Docks: As shown in Table 1, the docks at the various fish camps on Southern Indian Lake are built at elevations which vary from 839 - 847 feet, with the majority between 839 - 842 feet. Since the elevation of Southern Indian Lake could use to a maximum of 850 feet post regulation, all of these docks will be flooded, some of them by as much as 11 feet of water.

c) Remedial Action

With regard to the fish camp docks, it will be necessary to either rebuild or raise all of them since as mentioned above, none are at an elevation which is above 850 feet. The cost of raising and/or rebuilding these docks should be borne by Manitoba Hydro since they are directly responsible for the disruption involved.

6. Airstrips (see Map I)

a) Description

At the present time there are two airstrips in the Southern Indian Lake region, at South Indian Lake community and at Missi Falls.

The airstrip at South Indian Lake is owned by the Province of Manitoba and is located on the east side of the "Narrows" at latitude 56°48'N, Longitude 98°55'W. The runway is gravel over clay and is 2000 feet in length. A terminal building and warehouse facility are to be built at the airstrip as a part of the South Indian Lake development plan.

The airstrip at Missi Falls is scheduled for completion by early fall of 1973. No detailed information concerning this facility is available at present.

b) Hydro Development Effects

With regard to the airstrip at South Indian Lake, it is at an elevation of approximately 900 feet. Therefore it seems unlikely that the increase in water level (to a maximum elevation of 850 feet) will affect the airstrip in any way.

As a result of the lack of information regarding the airstrip at Missi Falls, no comment will be made regarding the possible implications of Hydro development on this facility.

7. Sea Plane Landing Bases (see Map I)

a) Description

The only sea plane landing base which will be operational after 1973 is at South Indian Lake community. As a part of the development program for the community, the sea plane base will be moved from its present location on the west side of the "Narrows" to the site of the new main dock (see C-5) on the east shore. The base will likely continue to be operated jointly by Midwest Airlines, Lambair and Manitoba Government Air Services. The length of the landing site will be unchanged at two miles.

b) Hydro Development Effects

Specific information concerning the post regulation turbulence and current velocities in the vicinity of the sea plane base site at South Indian Lake is not presently available. However, due to the fact that the Churchill River will be diverted via South Bay into a man made channel and hence the Rat-Burntwood River system, changes in existing current flow at the site of the sea plane base could occur with a maximum increase of 30,000 cfs being experienced. It may be useful to note here that an on-site inspection of the current flow in the vicinity of South Indian Lake community was done in early July, 1973 by the authors, at which time it was noted that there is presently very little current in the area of the sea plane base. Thus any increase in flow could alter the present conditions to a substantial degree. However, the nature of any altered current flow in the area of the sea plane base is unknown and therefore the effects of this factor on the facility cannot be assessed without more detailed information.

III. TRANSPORTATION SERVICES ANALYSIS: METHODOLOGY

A. Introduction

In the Southern Indian Lake - Rat-Burntwood Study area, the transportation network is limited but vital both for removal of resource products such as fish and for the importation of commodities such as foodstuffs. It is therefore essential that an investigation into the effects on these transportation services of Hydro development be undertaken.

B. Methodology

The analysis of services will be divided into a Regional component which will be concerned with outbound resource product traffic (such as forestry products, fish etc.) on an area-wide basis and a community component which will concern itself with inbound commodities (such as food, fuel, etc.) on an individual community basis. Each of these components is discussed below.

1. The Regional Component

The initial stage in this phase of the services analysis will be the identification of the regional resource base. In other words, the location of fishing grounds, harvestable forests, portential existing mine sites, etc. will be outlined.

Having identified the regional resource base, it will then be necessary to delineate for each resource in the region its relative location with respect to the existing and the expected transportation network as well as the nature of the operation required to remove the resource in each area.

The next phase of the regional analysis will be the establishment of a time sequence (possibly 20 years) for removal of each resource; this includes both the stages of development of the particular resource and any infrastructure requirements. An estimate will then be made of the annual potential traffic for each resource activity over the particular time sequence established.

The existing method of removing the particular resource product will then be outlined. This method of removal will be applicable even for resources not yet exploited in order to obtain a "status quo" situation.

With the use of the existing removal method, cost curves for annual potential traffic over the established time period will then be calculated for each resource. This set of curves will represent the "status quo" situation, ie. no extensions to the existing infrastructure and no Hydro development. (Call this situation A).

The next phase of the regional services analysis will be to outline a modified removal method(s) for each resource which will use both Hydro-initiated and non-Hydro initiated extensions to the transportation infrastructure.

Using this modified removal method(s), cost curves will be calculated for annual resource traffic potential. However, the Hydro-initiated infrastructure extensions will be assumed to have been initiated by other means, in order to obtain an estimate of the future transportation situation without Hydro development. (Call this situation B).

The final set of cost curves will be calculated for annual resource traffic potential using the same modified removal method(s) as in situation B. However, in this case they will be calculated on the basis that Hydro bears the cost of the portions of the extended infrastructure which are associated with hydro-electric development. (Call this situation C).

The next phase of this analysis will involve a comparison of cost curves for each situation. Initially, a choice will be made between situation A and situation B. This will be done by comparing the annual savings in freight costs which will result from an extended infrastructure as in situation B, with the annual cost of this extended infrastructure (without Hydro inputs). In other words, will the savings incurred as a result of the extended infrastructure justify the annual cost of that infrastructure? If the answer is "yes", situation B will be chosen. If the answer is "no", situation A (status quo) will be the choice for further analysis.

At this point, a comparison will be drawn between either situation A or situation B (depending on the choice above) and situation C (Hydro development inputs in terms of extended infrastructure). An estimate will be made of the alteration in annual freight costs (if any) which will result by comparing A or B with C. Also, the extra cost of the extended infrastructure which would result even with Hydro-initiated inputs, will be estimated. A comparison will then be drawn (as was done between situation A and situation B) between the annual savings (if any) in freight costs and the annual extended extra infrastructure costs (excluding Hydro-initiated infrastructure costs). This result will in turn be compared with the ratio obtained previously by using an extended infrastructure without Hydro inputs (situation A versus situation B).

The factor difference between the savings/extra cost ratio for extended infrastructure with Hydro inputs compared to the savings/ extra cost ratio for extended infrastructure without Hydro inputs will be a measure of the contribution of Hydro development to a specific type of resource removal activity.

2. The Community Component

The procedure used in this phase of the services analysis is similar to that used for the Regional Component, the differences being that imports instead of exports are considered in this section.

It must be noted that only the community of South Indian Lake will be the recipient of benefits which may accrue from Hydro-initiated infrastructure extensions. None of the other communities in the study area (Leaf Rapids, Nelson House, Thompson) will obtain extensions to the presently existing transportation infrastructure (with respect to the importation of commodities) as a result of Hydro development. Such being the case, only South Indian Lake will be considered in terms of a detailed analysis.

3. "Case Study" Example

As an aid in understanding the analysis procedure involved in this section, a "case study" of imports to South Indian Lake community has been included. The figures used in no way represent an accurate picture of freight rates or imports but are for demonstrative purposes only.

Case Study - Imports to S.I.L.

Aggregate Total of Imports - 400,000 lbs in 1973.

Assuming a constant demand for a 20 year period, the annual imports will remain at 400,000 lbs per year.

a) Existing Method: a combination of water (summer), air (summer and winter) and winter roads (winter).

Assume an aggregate average rate of $3.00/cwt. including infrastructure cost, therefore Existing Annual Cost (assuming constant freight rate)

$$= \$3.00 \times \frac{400{,}000}{100} = \$12{,}000$$

b) Extended Road Network (no Hydro input): assume construction cost to be $50,000/mile.

Cost of constructing Ruttan-South Bay road	- $ 2,000,000
Cost of constructing South Indian Lake extension	- 500,000
Total construction cost	- $ 2,500,000

Assume annual maintenance cost to be $50,000/year, therefore average annual cost of Ruttan-South Indian Lake road (20 year period)

$$= \frac{2{,}500{,}000}{20} + 50{,}000 = \$175{,}000/\text{year}$$

This cost would be born by agencies other than Hydro.

Freight costs: assume a truck rate of $1.00/cwt, therefore cost of freight

$$= \frac{400{,}000}{100} \times 1.00 = \$4{,}000$$

Savings over existing method (a)

$$\$12{,}000 - \$4{,}000 = \$8{,}000/\text{year}$$

Total annual costs of non-Hydro initiated road extension as above is $175,000/year,

$$\begin{array}{ccccc} \text{Savings} & / & \text{Costs} & & \text{Ratio} \\ = \dfrac{8{,}000}{175{,}000} & = & \dfrac{8}{175} & = & .05 \end{array}$$

This ratio indicates that the non-Hydro initiated extended road network freight cost savings are more than offset by the tremendous annual cost incurred in road construction and maintenance.

c) Extended Road Network (with Hydro inputs): assume costs are as in (b).

Total construction cost of Ruttan-South Bay road = $ 2,000,000

This will be paid by Hydro.

Cost of extension to South Indian Lake = 500,000

Annual maintenance cost = 50,000

Therefore total annual cost of road not paid for by Hydro

$$= \frac{500,000}{20} + 50,000 = \$75,000$$

Freight costs (as in (b)),

Saving over existing method = $ 8,000/year

Savings / Cost Ratio

$$= \frac{8,000}{75,000} = \frac{8}{75} = .11$$

This indicates that Hydro-initiated infrastructure will have the effect of reducing the cost of the Ruttan-South Indian Lake road by $100,000/year (the non-Hydro inputs total cost of $175,000 annually minus the total cost of $75,000 annually when Hydro inputs are considered) and increasing the savings/cost ratio by more than a factor of 2.

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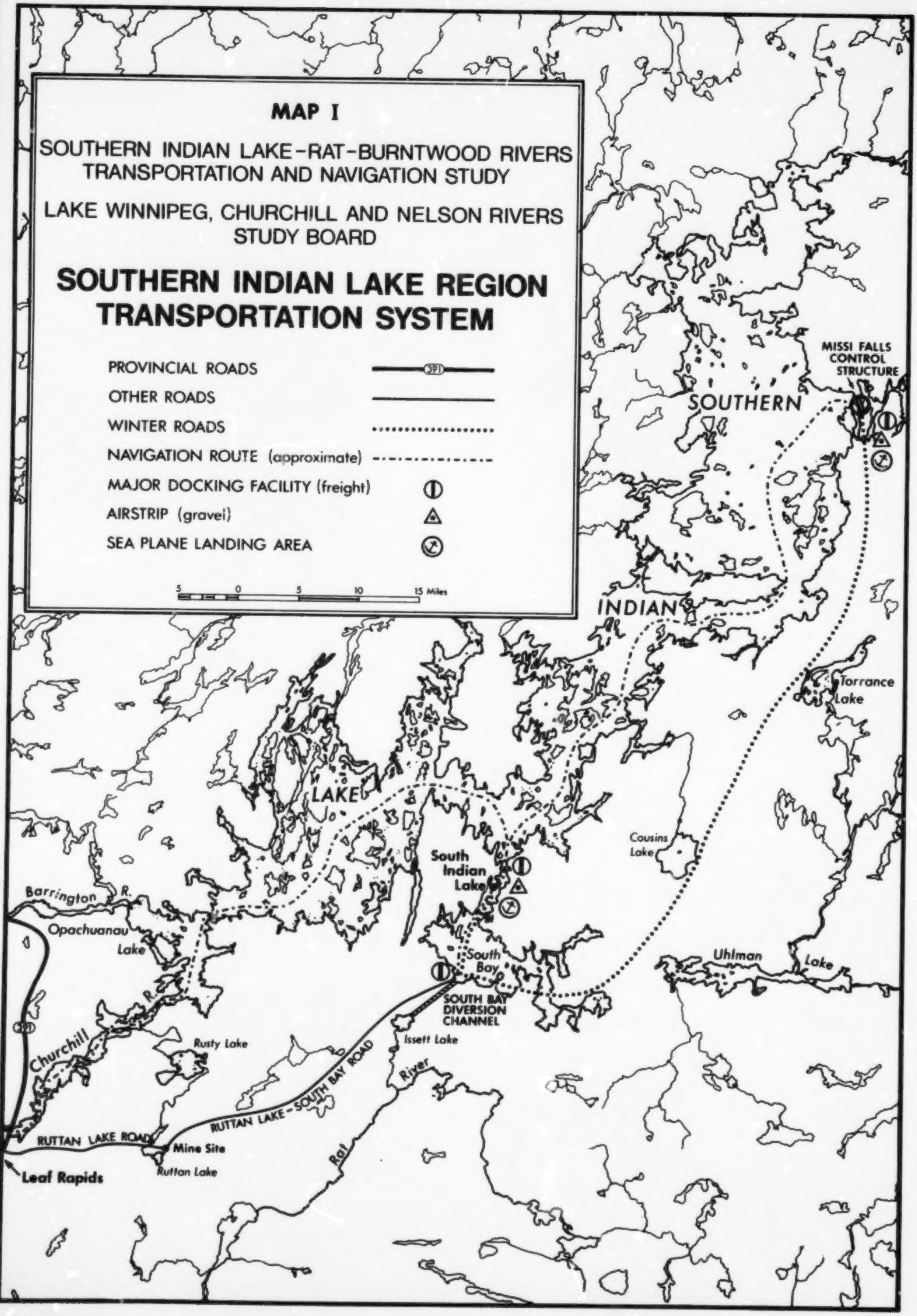
APPENDIX

MAP I:

MAP OF SOUTHERN INDIAN LAKE

REGION TRANSPORTATION SYSTEM



MAP I

SOUTHERN INDIAN LAKE-RAT-BURNTWOOD RIVERS TRANSPORTATION AND NAVIGATION STUDY

LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SOUTHERN INDIAN LAKE REGION TRANSPORTATION SYSTEM

PROVINCIAL ROADS
391
OTHER ROADS
WINTER ROADS
NAVIGATION ROUTE (approximate)
MAJOR DOCKING FACILITY (freight)
AIRSTRIP (gravel)
SEA PLANE LANDING AREA
5
0
5
10
15 Miles
MISSI FALLS CONTROL STRUCTURE
SOUTHERN
INDIAN
LAKE
Torrance Lake
Cousins Lake
South Indian Lake
Barrington R.
Opachuanau Lake
South Bay
SOUTH BAY DIVERSION CHANNEL
Uhlman Lake
Issett Lake
Churchill R.
391
Rusty Lake
Rat River
RUTTAN LAKE-SOUTH BAY ROAD
RUTTAN LAKE ROAD
Mine Site
Ruttan Lake
Leaf Rapids

APPENDIX 4 - O

SOUTHERN INDIAN LAKE -
RAT-BURNTWOOD DIVERSION
TRANSPORTATION AND NAVIGATION STUDY
(PART TWO)

SOUTHERN INDIAN LAKE - RAT-BURNTWOOD DIVERSION
TRANSPORTATION AND NAVIGATION STUDY
PART TWO

by

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April, 1974

for

THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SPECIAL NOTE

THE CONCLUSIONS AND RECOMMENDATIONS CONTAINED IN THIS APPENDIX ARE THOSE OF THE AUTHOR(S) AND ARE NOT NECESSARILY THE SAME AS THE CONCLUSIONS AND RECOMMENDATIONS OF THE LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD AS EXPRESSED IN THE SUMMARY REPORT AND THE TECHNICAL REPORT.

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2. Provincial Government Agencies

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Manitoba Department of Highways.

Manitoba Department of Co-operative Development.

3. Others

Mr. F. F. Saccomanno, associated with the Transportation and Navigation Study, August, 1973 - August, 1974.

I INTRODUCTION

As a component of the overall study undertaken by the Lake Winnipeg, Churchill and Nelson Rivers Study Board, this report contains the results of the second of a two-part investigation (Part I was submitted in October, 1973) into the implications of the Churchill River Diversion hydro-electric development program for existing and proposed transportation and navigation facilities and services in the Southern Indian Lake - Rat-Burntwood Diversion Study Area.

This report consists of two sections. Section II contains an examination of the effects of the Churchill River Diversion Hydro project on the physical transportation infrastructure in the Rat-Burntwood Diversion region of the Southern Indian Lake - Rat-Burntwood Study Area (see Part I, submitted October, 1973, for an examination of the Southern Indian Lake region transportation infrastructure).

Section III of this report includes an analysis of the effects of Hydro development on transportation services (including both resource product removal and commodity importation) in the Southern Indian Lake - Rat-Burntwood Study Area.

II RAT-BURNTWOOD DIVERSION REGION TRANSPORTATION INFRASTRUCTURE ANALYSIS

The method of approach to be used in examining the effects of Hydro development on the transportation infrastructure in the Rat-Burntwood Diversion region of the study area has been previously described in Part I of this investigation (submitted October, 1973). However, for purpose of clarity this method is again briefly outlined.

The infrastructure is divided into six basic components, namely: regional all-weather roads, intra-community roads, navigation, docks and wharves, airstrips, sea plane landing bases, and each component is described fully. The Hydro development effect on each transportation infrastructure component is then discussed with regard to both direct and indirect ramifications to the area concerned (if any). Finally, any remedial action deemed necessary resulting from Hydro development effects is identified in terms of the type and cost (where possible) of this action.

A. Regional All-Weather Roads

1. Description

In the Rat-Burntwood Diversion region of the study area only one facility could be considered as a regional all-weather road. This facility is the portion of Provincial Road 391 which connects the communities of Thompson, Nelson House (via a 6.4 mile access road), Leaf Rapids (a distance of 132 miles from Thompson) and Lynn Lake (a distance of 196 miles from Thompson) with the Provincial Highway network (see Appendix, Map I). The section of this highway from Thompson to Nelson House has been open since approximately June,1973 as an all-weather road under the "secondary paved or gravel"[1] classification (two lanes, aligned for speeds of 60 m.p.h., surface gravel or asphalt), with the surface in this case being gravel. The remaining section of this road which had been classified as "pioneer"[2] (no vertical alignment, compacted earth surface) was to be up to the status of secondary gravel by approximately October 15, 1973.[3] The opening of the road allows all-weather access by vehicular traffic (private and commercial) to the communities of Leaf Rapids and Lynn Lake via Thompson, thereby opening up this region to the rest of Manitoba and beyond.

It is expected that the entire section of Provincial Road 391 from Thompson to Lynn Lake will be gradually upgraded to the status of a "primary gravel" road (alignment for speeds up to 70 m.p.h.) as a part of the Department of Highways program of northern road construction.

2. Hydro Development Effects

The forebays which will result from the control structures at Notigi, Wuskwatim and Manasan will cause a certain amount of flooding along the Rat-Burntwood diversion route. Certain sections of the Thompson-Lynn Lake road (PR 391) approach the above forebays and as such could be flood susceptible. These sections include: (see Map I) Footprint River to Notigi, the Nelson House access road (to be examined under the Intra Community Roads Section, IIB) and immediately north of

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[1] Manitoba Highways Department classification.

[2] Ibid.

[3] Winnipeg Free Press, September 28, 1973. The road was reported open to traffic early in November. Winnipeg Free Press, November 8, 1973.

Thompson.

With regard to the Footprint River - Notigi section, according to the Manitoba Department of Highways, this portion "will not be affected by flooding due to the Hydro development as Manitoba Hydro are financing additional works in the vicinity of the Notigi Site such as causeway construction and rock armament on the existing grade where high water could cause erosion damage".[4]

The portion of road immediately north of the city of Thompson which will be affected begins four miles from the city and is approximately four miles in length. It is estimated that the forebay created by a control structure at Manasan (see Map I) will cause this portion of road to be flooded, regardless of any proposed dyking program suggested by the Baracos-Galay report, by as much as forty feet of water.[5]

3. Remedial Action

Definite remedial action will be required for the portion of PR 391 north of Thompson which will be flooded by the Manasan reservoir. This action must come in the form of either an approximate ten mile rerouting of the affected portion of road so as to place it beyond the flooded area or the upgrading of this road section to an elevation well above the maximum water level. In either case the accompanying cost of the remedial action should be borne by Manitoba Hydro.

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[4] Letter to authors from Manitoba Department of Highways, August 14, 1973.

[5] "Effects of Increased Flow on the Burntwood River near Thompson, Manitoba", by A. Baracos and V. Galay.

B. Intra-Community Roads

1. Description

a) Thompson

The City of Thompson, with a population in excess of 20,000,[6] has a rather extensive paved road system, most of which is at an elevation of 675 feet or higher. At present, no portion of this road system lies on the north shore of the Burntwood River with the exception of PR 391 and its airport extension.

b) Nelson House

Nelson House (population 1,300[7]), which is situated on Footprint Lake (see Map I), is a community which has a very large surface area. Most of the dwellings are situated along the lake shore, with the exception of a portion of the south-west section of the community. The main road servicing this community follows the basic configuration of the shoreline. There are also branches of this road to several areas within the community.

The community of Nelson House is linked to PR 391 by an access road 6.4 miles in length (see Map I). This road was built for the most part at an elevation of 820 feet or higher.

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[6] Study Area Facts, Lake Winnipeg, Churchill and Nelson Rivers Study Board.

[7] Study Area Facts, Lake Winnipeg, Churchill and Nelson Rivers Study Board.

2. Hydro Development Effects

a) Thompson

The creation of a large lake (elevation 700 feet[8]) as a result of the construction of a control structure at Manasan could possibly result in a flooding problem at Thompson. However, this lake is to be contained by a series of dykes built to an elevation of 700 - 710 feet and no flooding of the community is foreseen with the exception of a portion of the Burntwood River shoreline.[9] This latter flooding will not be primarily the result of the Manasan forebay but will be caused, for the most part by the creation of a reservoir (elevation 610 feet) in connection with the First Rapids control structure (see Map I).

With the above information in mind, it is logical to conclude that since the townsite will be free of flooding, the Thompson municipal road system will also be unaffected by Hydro development.

b) Nelson House

The construction of a control structure at Wuskwatim (see Map I) will result in the raising of the level of Footprint Lake to approximately 806 - 810 feet, according to a report titled "Anticipated Shoreline Effects of Raised Lake Levels at Nelson House, Manitoba" by Professors V. Galay and A. Baracos of the University of Manitoba. Accordingly, this will result in an increase in the water level of Footprint Lake (upon which Nelson House is situated) of between 22.5 and 26.5 feet (from its present elevation of 783.5 feet to 806 - 810 feet).

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[8] Information for this and subsequent forebay elevations obtained from a letter to authors from Water Resources Branch, November 9, 1973.

[9] Ibid.

The internal community road network described earlier will be seriously affected by this increase in the level of Footprint Lake. Sections of road in three areas will likely be flooded.[10] These include: a 600 foot section midpoint at approximately latitude 55° 47' 40" and longitude 98° 53' 20" (flooding in this area will isolate the southern portion of the community from the mainland); an 800 foot section midpoint at approximately latitude 55° 47' 45" and longitude 98° 52' 10"; an 1800 foot section midpoint at approximately latitude 55° 48' 00" and longitude 98° 51' 10".

The Nelson House access road, connecting the community with PR 391, will experience a certain amount of flooding. The three sections so affected are: a 1200 foot section midpoint at approximately latitude 55° 49' 25" and longitude 98° 51' 30"; an 800 foot section midpoint at approximately latitude 55° 49' 55" and longitude 98° 51' 25"; a 200 foot section midpoint at approximately latitude 55° 50' 05" and longitude 98° 51' 25".

3. Remedial Action

Remedial action is required for both the local road system at Nelson House and the Nelson House access road. This action could take the form of upgrading the above mentioned sections of both facilities which will experience flooding due to the increased water levels on

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[10] All subsequent data on both local roads and the access road is based on photo mosaic maps from the Burntwood River mapping project and on "Anticipated Shoreline Effects of the Raised Lake Levels at Nelson House, Manitoba" by V. Galay and A. Baracos.

Footprint Lake. However, the section of roadway which is included in the completely flooded area (latitude 55° 47' 40", longitude 98° 53' 20") will have to be replaced by a bridge or causeway. Any costs associated with this upgrading and bridge or causeway construction should be borne by Manitoba Hydro as the agency responsible for the flooding.

C. Navigation

1. Description

In the Rat-Burntwood region of the study area, navigation, apart from small motor boats and canoes, is confined to the major lakes along the Rat and Burntwood Rivers system and is associated primarily with the commercial fishery. Karsakuwigumak Lake, Pemichigamau Lake, Rat Lake and Mynarski Lake (see Map I) are all lakes which may be fished by members of the South Indian Lake Fisheries Cooperative. Other lakes in this region (see Map I) including Notigi, Wapisu, Threepoint, Footprint and Wuskwatim may be fished on either a commercial or non-commercial basis by local residents, either for export or internal (domestic) use. However, specific information regarding the type of fishing which takes place on these lakes is unavailable. With regard to the four lakes associated with the South Indian Lake Fisheries Cooperative, any navigation which takes place, in terms of the fishery, will likely be internal to each lake with the exception of movement from one lake to another for the purposes of finding new sources of fish. Specific information regarding this intra and inter-lake movement is unavailable with regard to routes followed and frequency of movement.

It should also be noted that at present it is physically possible to navigate the entire Rat and Burntwood Rivers system from Issett Lake to Thompson and beyond by canoe or small motor boat. However, the frequency of such complete or even partial navigation is impossible to ascertain.

2. Hydro Development Effects

The construction of control structures at Notigi, Wuskwatim, Manasan and First Rapids (see Map I) will create forebays which are far above the present level of the lakes and rivers in the Rat-Burntwood Diversion region. In effect, a large lake will be formed upstream of each control structure with approximate maximum elevations of 850 feet for the Notigi forebay (which includes Pemichigamau, Karsakuwigumak, Rat, Mynarski and Notigi Lakes); 810 feet for the Wuskwatim forebay (including Wapisu, Threepoint, Footprint and Wuskwatim Lakes); 700 feet for the Manasan forebay; and 610 feet for the forebays at First Rapids.

The creation of the above forebays will result in the submergence of a certain amount of what is presently the shoreline of the above mentioned lakes. Since the clearing program envisioned for the area will consist mostly of cutting the trees and not cutting and burning, much of the debris resulting from the cutting will remain in the lakes for many years. This will be the case regardless of the post diversion program of collecting such debris, due to the length of shoreline to be affected. It should also be noted that the above clearing program has been developed for the South Bay to Notigi Lake section of the diversion route only. Plans for clearing the region from Notigi Lake to First Rapids are unknown at this time.

The effect of the flooding of shorelines on internal lake navigation, especially on lakes which could be involved in the commercial fishery, could be quite significant. The sections of shoreline which will be cut but not burned will become difficult landing areas, due to a large amount of floating debris, until any long range program of collecting the debris has been completed. Also large, cut trees which may float out into the lakes could be navigational hazards, possibly causing damage to fishing vessels. The nets laid by commercial fishermen could also become entangled in floating debris and damaged.

One final, if minor, effect of the construction of the various control structures will be the prevention of long distance navigation of the Rat-Burntwood River system without lengthy portages at each Hydro site.

3. Remedial Action

As mentioned above, the most serious detrimental effects which may result from the Rat-Burntwood diversion concerning navigation will be caused by floating debris left in the lakes after the construction of the various control structures. If this debris could be contained in specific areas along the shoreline by means of log booms or some other appropriate method, perhaps shoreline accessibility would be improved along with the elimination of any hazards to navigation and fishing.

Little can be done in terms of the barriers which the control structures will present to long distance navigation other than to provide some type of boat landing/launch area at each control structure.

D. Docks and Wharves

1. Description

The Rat-Burntwood Diversion region contains a number of docking facilities, all of which are associated with either fish camps, Nelson House or Thompson. Three docking facilities associated with fish camps in this region are: a 13 foot dock on Rat Lake (Camp 17) at an elevation of 824 feet (this dock was missing in 1972); a 20 foot dock on Wapisu Lake (Camp 25) at an elevation of 790 feet (damaged in 1972); a 10 foot dock on Wuskwatim Lake (Camp 26) at an elevation of 773 feet.[11]

The community of Nelson House has several minor landing docks and a larger dock (located in the southern portion of the community opposite the nursing station). All of these facilities are at an elevation of approximately 800 feet or lower.

The major dock facilities at the City of Thompson are associated with the sea plane bases on the north shore of the Burntwood River east of the bridge. Much of this area is below the 620 foot elevation level according to a report by Professors V. Galay and A. Baracos of the Department of Civil Engineering, University of Manitoba.[12]

2. Hydro Development Effects

The aforementioned docking facilities associated with fish camps on Rat, Wapisu and Wuskwatim Lakes are all at elevations below the maximum forebay elevations which will result from the construction of control structures at Notigi (for the Rat Lake dock) and Wuskwatim (for the docks on Wapisu and Wuskwatim Lakes). Thus these structures will be unusable post regulation.

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[11] Information source: "Real Property Assessment - South Indian Lake - Rat-Burntwood Diversion Route", preliminary report prepared by Water Resources Branch.

[12] "Effects of Increased Flow in the Burntwood River Near Thompson, Manitoba", by V. Galay and A. Baracos.

With regard to the Nelson House docking facilities, since all are at an elevation of 800 feet or lower as mentioned previously, and since the new elevation of Footprint Lake when the Wuskwatim control structure is built will be approximately 806 - 810 feet under ice free conditions (see section B 2(b)), all docking and landing facilities at Nelson House will be unusable after such construction has taken place.

According to Baracos and Galay[13], the level of the Burntwood River at Thompson (under the effect of the First Rapids Dam and increased flow) will rise to the extent that a strip of land 400 feet wide along the north bank of the river, down stream of the bridge, will be inundated. This strip of land includes the docking facilities associated with the sea plane bases, discussed above. These facilities will therefore be rendered unusable.

3. Remedial Action

The inundated docks associated with the commercial fishery on Rat, Wapisu and Wuskwatim Lakes should be replaced at the expense of Manitoba Hydro, if these facilities are to be used in the future. This factor will likely be determined after the investigation into the effects of Hydro development on the fishery in this area is completed by the limnology-fisheries component of the Study Board.

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[13] Ibid.

The docks at Nelson House and the docking facilities associated with the sea plane base at Thompson will all require reconstruction or removal to a higher elevation. The costs associated with such remedial action should be borne by Manitoba Hydro.

E. Airstrips

1. Description

In the Rat-Burntwood Diversion region of the study area, there are presently two airstrips: at Nelson House and at Thompson.

The airstrip at Nelson House is located in the north-east corner of the settlement at the junction of the community road and the access road to PR 391. This facility is owned by the Province of Manitoba. It has a runway length of 3,000 feet and its surface composition is a mixture of clay and sand which is slippery when wet. There are no runway markers, lighting or navigation indicators other than a wind sock. The entire length of the airstrip is at an elevation of 825 feet[14] or greater.

The airport at Thompson ranks as one of the major air facilities in northern Manitoba. It is operated by the Local Government District of Mystery Lake and is classified as an IFR installation (Instrument Flying Rules, i.e. operable day or night and under conditions of restricted visibility). Auxiliary facilities include a passenger and freight terminal as well as radio aids to navigation. The facility is located approximately five miles by road north of the City of Thompson. The surface composition of both the runway and taxiway is asphalt and the runway length is 5,400 feet. The major portion of the runway is at an elevation of 705 feet or greater. However, small sections of both ends (south-west and north-east) of the runway are below 700 feet.

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[14] "Anticipated Shoreline Effects of Raised Lake Levels at Nelson House, Manitoba", by A. Baracos and V. Galay.

2. Hydro Development Effects

The airstrip at Nelson House, being at an elevation of 825 feet or greater, will be unaffected by the raising of the level of Footprint Lake. However, a portion of the lake shore directly adjacent to the end of the airstrip on the south-east will be inundated.

This shore area is presently in an unstable condition, according to a previously cited study by Professors Galay and Baracos.[15] Thus the rise in water level could increase this instability and possibly cause slumping or erosion of the bank. This could result in a possible hazard to aircraft approaching the airstrip from this direction.

The runway at the Thompson airstrip is, for most of its length, at an elevation above the maximum Manasan forebay level of 700 feet. However, the south-west end of the runway is between 690 and 700 feet in elevation and as such could be affected to a minor degree by flooding.

3. Remedial Action

In order to prevent the erosion of the lake shore immediately adjacent to the south-east end of the Nelson House airstrip, remedial action will be necessary. As suggested by Baracos and Galay: "It is possible to effectively protect banks from erosion by the use of rip-rap".[16] This rip-rap can be placed before the flooding takes place or immediately thereafter[17] and will eliminate the potential landing hazard at Nelson House airstrip. The cost of this remedial action should be borne by Manitoba Hydro.

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[15] Ibid.

[16] Ibid.

The south-west portion of the Thompson airport runway which is between 690 and 700 feet in elevation could be adequately protected by a certain amount of dyking, as suggested in another study by Baracos and Galay.[18] This too, should be the financial responsibility of Manitoba Hydro.

F. Sea Plane Bases

1. Description

There are presently two sea plane landing bases in the Rat-Burntwood diversion region of the study area: at Nelson House and at Thompson.

The sea plane base at Nelson House is situated immediately adjacent to the southern portion of the community, on Footprint Lake. This base is jointly operated by Ilford-Riverton Airways and Lambair, and is open from approximately the last week in May to the last week in October. The main dock serving the incoming aircraft is in front of the nursing station (see section D). According to the Air Radio and Technical Services Division, Manitoba Department of Mines, Resources and Environmental Management, operating conditions at this base are good; however, caution is required as a result of reefs in certain areas of Footprint Lake.[19]

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[17] Ibid.

[18] "Effects of Increased Flow in the Burntwood River Near Thompson, Manitoba", by A. Baracos and V. Galay.

As indicated in the discussion of docking facilities at Thompson (see section D), the sea plane base at this community is located on the Burntwood River approximately 1,000 feet downstream of the bridge. It consists of three separate facilities operated by Ilford-Riverton Airways, Lambair and Manitoba Government Air Services respectively. The usable yearly time span of the facilities is similar to that for Nelson House, with local weather conditions governing the exact dates. The Air Radio and Technical Division states that caution should be maintained during landing due to fast water, especially near the bridge area.[20]

2. Hydro Development Effects

As a result of the construction of the Wuskwatim control structure, the water level on Footprint Lake will increase by as much as 26.5 feet (see section B 2(b)). This rise in the water level could remove the above-mentioned hazard caused by reefs which are presently near the surface but which will be considerably below surface post regulation. However, low islands and/or rock outcrops which are presently well above the surface of the lake will become fully or partially inundated with the increase in water levels and could result in the creation of new reefs, presenting a possible hazard to aircraft landing. According to Manitoba Hydro, the surface velocity in the Footprint Lake area will increase from .5 fps prior to regulation to 1.5 fps post regulation.[21] Both Canada Transport and private operators are of the view that such a velocity increase will not affect the Nelson House sea plane base.[22]

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[19] Source: Manitoba Flight Information Map prepared by Air Radio and Technical Division.

[20] Ibid.

The diversion of the Churchill River into the Rat-Burntwood River system will result, at times, in an increase in flow of approximately 30,000 cfs above the present ten year mean value of 4,000 cfs, coupled with a current velocity increase from 1.0 to 2.5 fps.[23] The former will result in the formation of eddies or turbulence in the area downstream of the bridge in the vicinity of the sea plane landing areas on the Burntwood River at Thompson and could contribute to hazardous landing conditions due to the extention of high lateral forces on the aircraft during landing. The latter, according to sources cited earlier,[24] should not have any effect on sea plane operations.

3. Remedial Action

The possible creation of new reefs on Footprint Lake after regulation which could be hazardous to seaplane landings and take-offs could be offset by a pre-regulation program of identifying any islands and/or rock outcrops in the vicinity of the present landing areas that will be just below the surface when the water level is increased. This would save the more difficult tasks of identifying such hazards post regulation, possibly after damage to aircraft whose pilots were unfamiliar with the location of new reefs.

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[21] Letter from Manitoba Hydro to Study Director, December 19, 1973.

[22] Ibid.

[23] Study Area Facts, Lake Winnipeg, Churchill and Nelson Rivers Study Board, January, 1973.

[24] Letter from Manitoba Hydro to Study Director, December 19, 1973.

Pilots of aircraft using the Thompson seaplane base may have to be more cautious after the diversion is completed since little can be done to alter the new flow constraints which will result.

III SOUTHERN INDIAN LAKE - RAT-BURNTWOOD DIVERSION ROUTE TRANSPORTATION SERVICES ANALYSIS

A. Outline of Method of Approach

The transportation services analysis will be divided into two sections: a community component which is concerned with importation of commodities to any communities in the study area whose methods of importation could be altered by Hydro development, and a regional component concerned with resource product removal in the entire study area. The method of approach discussed in detail in Part One of the Southern Indian Lake - Rat-Burntwood Diversion Transportation and Navigation Study (submitted in October, 1973), hereafter referred to as Part One, remains essentially unchanged with regard to the community component. However, the analysis of resource product removal on a regional basis (the regional component) will be altered due to a revision of the technique involved. A discussion of the method of approach to be used for each component follows.

1. The Community Component

As indicated in Part One, it should be noted that Hydro initiated transportation infrastructure extensions are of direct consequence only to the community of South Indian Lake. Neither Nelson House nor Thompson will acquire extensions to the present transportation infrastructure (directly related to commodity importation) as a result of Hydro development. Due to this fact a detailed analysis of commodity importation will be done only for South Indian Lake community.

The method of approach to be used involves several stages of analytical procedure.

The first stage is an identification of a twenty year time sequence of importation and the establishment of an estimated annual traffic volume for that particular time span.

Subsequently, cost curves are developed for this annual import traffic volume (for a twenty year span) utilizing the methods and costs of importation which presently exist. This is called, for the purposes of this analysis, situation "X".

The next phase of the analysis involves the identification of possible Hydro-initiated and non Hydro-initiated transportation infrastructure extensions which could have ramifications for commodity importation. Cost curves are then developed for the above annual commodity traffic (over a twenty year time frame), using the infrastructure extensions, in the following separate ways:

(a) by assuming that the Hydro-initiated extensions were provided by other sources in order to obtain an estimate of the future situation without Hydro development inputs (this will be known as situation "Y").

(b) by assuming that Hydro bears the cost of the portions of extended infrastructure associated with Hydro development in order to illustrate the economic effect of Hydro development inputs (this will be known as situation "Z").

The subsequent stage involves a comparison of the three sets of cost curves developed above. Initially situation "X" is compared with situation "Y" to determine if the savings involved in the improved importation procedure (resulting from extended transportation infrastructure) are justified by its higher capital cost. If this is found to be the case, situation "Y" is chosen for further analysis. If it is not found to be justified, situation "X" is chosen.

At this stage, depending on the above choice, situation "X" or situation "Y" is compared with situation "Z" (i.e. the existing method or the extended infrastructure with no Hydro inputs is compared with the extended infrastructure including Hydro inputs) in the following manner:

(i) an estimate is made of the annual alteration in freight costs which result from a comparison of "X" or "Y" with "Z".

(ii) extra, non-Hydro initiated infrastructure costs are estimated.

(iii) a comparison is drawn between annual freight cost savings and non-Hydro initiated infrastructure costs.

(iv) the result of (iii) above is then compared with the ratio of savings to costs obtained by comparing "X" with "Y".

The factor difference between the savings/extra cost ratio for extended transportation infrastructure with Hydro inputs and the savings/extra cost ratio for extended infrastructure without Hydro inputs is a measure of the economic contribution of Hydro development to commodity importation to South Indian Lake.

2. The Regional Component

The original intent (discussed in Part One) was to consider the analysis of the export of resource products on a regional basis in a similar manner to the importation of commodities analysis discussed above. However, upon a more detailed examination of the relevant information, it was concluded that the movement of resource products did not lend itself readily to the above analytical procedure. This was due to several factors which differed with each type of resource product considered, one of which was the varying amount of information available for each resource. Therefore, the analysis of the removal of fish will differ from forest products and both will differ from minerals. Each method of analysis will be discussed under its appropriate heading to avoid repetition and possible lack of clarity.

B. The Community Component - South Indian Lake

1. Description of Community

The community of South Indian Lake (population 600)[25] presently occupies both sides of a portion of the channel which connects Southern Indian Lake with South Bay (see Map I). This section of the channel, on which the community lies is known as the "Narrows" and will be referred to as such throughout this section.

Recently, an extensive redevelopment program has commenced at the community. When completed, this redevelopment, which is being undertaken by the Provincial Department of Northern Affairs, will see the relocation of the present shopping and nursing facilities from their existing site on the west bank of the Narrows to the east bank. Included in the same "town center" complex will be a new school, gymnasium, skating rink and other community amenities. As well, new housing sites will be developed along the east bank with pedestrian-oriented road access to both the town center and the airstrip.

The effects of Hydro development on the physical transportation infrastructure of South Indian Lake were discussed in detail in Part I. The main adverse effect was thought to be the reduction of the winter ice cover in the South Bay - Narrows area post-regulation, causing a disruption of intra community and inter community winter travel.[26]

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[25] Study Area Facts, Lake Winnipeg, Churchill and Nelson Rivers Study Board, January, 1973.

[26] Southern Indian Lake - Rat-Burntwood Diversion Transportation and Navigation Study, Part I, October, 1973.

2. Analysis

The major importers of commodities into the Southern Indian Lake area are the Hudson's Bay Company and the South Indian Lake Fisheries Co-operative. The latter importer is mainly concerned with supplying the various commercial fishing camps while the former provides the only retail outlet in the community of South Indian Lake.

With regard to the future demand for imports to the community, as a result of discussion with representatives of the Manitoba Department of Northern Affairs, it was deemed advisable to consider the demand to be constant at present volumes over the twenty year time sequence to be considered for the analysis. It was thought that the number of deaths and migrants from the community would be approximately balanced with the number of births and thus a constant demand for commodities was considered to be a reasonable estimate for the next twenty years.[27] The tonnage which will be used as the constant twenty year annual importation volume is based on information received from the Northern Stores division of the Hudson's Bay Company. The breakdown of this tonnage (for 1972-73) is as follows:

Perishables	30 tons
Dry Groceries	130 tons
Dry Goods	40 tons
Petroleum Products	50 tons
Total	250 tons

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[27] Information received in informal discussion with officials of Manitoba Department of Northern Affairs.

Imports by South Indian Lake Fisheries Co-operative are distributed to the various fish camps on the Lake via the Co-op freight boats during the summer commercial fishing season.[28] Since this commodity importation is confined to the fish camps and since very little finds its way to South Indian Lake community, it will not be considered as part of the community component analysis.

Tables I - IV and Graph I represent the annual transport cost of importing various commodities over a twenty year time sequence using the methods of importation and transportation infrastructure presently utilized (1973-74). Freight rates are assumed constant over the twenty year period for analysis purposes.[29] The methods and routes are:

a) In winter, dry groceries and dry goods are shipped by truck from Winnipeg via PTH 6, PR 391, the Leaf Rapids - South Bay road and the South Bay - South Indian Lake winter road.

b) In summer, dry groceries and dry goods are shipped by air from Lynn Lake.

c) Perishables are shipped year-round by air from Lynn Lake.

d) Petroleum products are shipped in winter from Thompson[30] by truck via PR 391, the Leaf Rapids - South Bay road and the South Bay - South

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[28] Information received from Manitoba Department of Cooperative Development, July, 1973.

[29] Rates for the modes involved have historically been subject to change, usually by way of increase. However, it is difficult to predict with any degree of accuracy to what extent the rates will change over a twenty year time sequence. Thus, for the purposes of this analysis, the rates will be assumed constant at 1973 figures.

[30] Social and Economic Impact of the Nelson River Hydro Development, Department of Northern Affairs, June, 1973.

Indian Lake winter road.

According to the Hudson's Bay Company,[31] the winter summer percentage breakdown for total imports is approximately fifty percent shipped in winter and fifty percent in summer. The exception is petroleum which is shipped almost exclusively in winter. It will be assumed that the fifty/fifty breakdown applies to each commodity type as well as to the total volume.

The next phase of the analysis of commodity importation to South Indian Lake involves the identification of any infrastructure extensions which could have ramifications for this importation. In the Southern Indian Lake - Rat-Burntwood Diversion Study Area, the major Hydro-initiated surface transportation extension is the Ruttan Lake - South Bay all-weather road which was scheduled for completion in the fall of 1973.[32] This extension was built by the Manitoba Department of Highways at a cost to Manitoba Hydro of $2.25 million (with annual maintenance of $40,000) "to provide access to the Manitoba Hydro diversion channel construction site as well as to possibly provide the initial link in a barge operation to supply the Missi Falls control structure site.[33] This new all-weather road brings the community of South Indian Lake to within ten miles of the Provincial Highway network. This latter fact suggests a possible non-Hydro initiated extension of the Ruttan Lake - South Bay road to the community should circumstances

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[31] Letter to authors from Hudson's Bay Company, December, 1972.

[32] Southern Indian Lake - Rat-Burntwood Diversion Transportation and Navigation Study, Part I, October, 1973.

[33] Ibid.

TABLE I

IMPORTATION COSTS-PRESENT IMPORTATION METHOD

(1973-92)

SOUTH INDIAN LAKE

PERISHABLES

Year	Total Tonnage	Winter Tonnage	Winter Unit Cost $/Ton	Total Winter Cost $	Summer Tonnage	Summer Unit Cost $/Ton	Total Summer Cost $	Total Annual Cost $
1973	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1974	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1975	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1976	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1977	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1978	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1979	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1980	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1981	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1982	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1983	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1984	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1985	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1986	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1987	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1988	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1989	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1990	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1991	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1992	30	15	140.00	2100.00	15	140.00	2100.00	4200.00

Rate Sources: Hudson's Bay Company Northern Stores Division

Social and Economic Impact of the Nelson River Hydro Development

TABLE II

IMPORTATION COSTS-PRESENT IMPORTATION METHOD

(1973-92)

SOUTH INDIAN LAKE

DRY GROCERIES

Year	Total Tonnage	Winter Tonnage	Winter Unit Cost $/Ton	Total Winter Cost $	Tonnage	Summer Unit Cost $/Ton	Total Summer Cost $	Total Annual Cost $
1973	130	65	80.00	5200.00	65	120.00	7800.00	13000.00
1974	130	65	80.00	5200.00	65	120.00	7800.00	13000.00
1975	130	65	80.00	5200.00	65	120.00	7800.00	13000.00
1976	130	65	80.00	5200.00	65	120.00	7800.00	13000.00
1977	130	65	80.00	5200.00	65	120.00	7800.00	13000.00
1978	130	65	80.00	5200.00	65	120.00	7800.00	13000.00
1979	130	65	80.00	5200.00	65	120.00	7800.00	13000.00
1980	130	65	80.00	5200.00	65	120.00	7800.00	13000.00
1981	130	65	80.00	5200.00	65	120.00	7800.00	13000.00
1982	130	65	80.00	5200.00	65	120.00	7800.00	13000.00
1983	130	65	80.00	5200.00	65	120.00	7800.00	13000.00
1984	130	65	80.00	5200.00	65	120.00	7800.00	13000.00
1985	130	65	80.00	5200.00	65	120.00	7800.00	13000.00
1986	130	65	80.00	5200.00	65	120.00	7800.00	13000.00
1987	130	65	80.00	5200.00	65	120.00	7800.00	13000.00
1988	130	65	80.00	5200.00	65	120.00	7800.00	13000.00
1989	130	65	80.00	5200.00	65	120.00	7800.00	13000.00
1990	130	65	80.00	5200.00	65	120.00	7800.00	13000.00
1991	130	65	80.00	5200.00	65	120.00	7800.00	13000.00
1992	130	65	80.00	5200.00	65	120.00	7800.00	13000.00

Rate Sources: See Table I

TABLE III

IMPORTATION COSTS-PRESENT IMPORTATION METHOD

(1973-92)

SOUTH INDIAN LAKE

DRY GOODS

Year	Total Tonnage	Winter Tonnage	Winter Unit Cost $/Ton	Total Winter Cost $	Summer Tonnage	Summer Unit Cost $/Ton	Total Summer Cost $	Total Annual Cost $
1973	40	20	80.00	1600.00	20	120.00	2400.00	4200.00
1974	40	20	80.00	1600.00	20	120.00	2400.00	4200.00
1975	40	20	80.00	1600.00	20	120.00	2400.00	4200.00
1976	40	20	80.00	1600.00	20	120.00	2400.00	4200.00
1977	40	20	80.00	1600.00	20	120.00	2400.00	4200.00
1978	40	20	80.00	1600.00	20	120.00	2400.00	4200.00
1979	40	20	80.00	1600.00	20	120.00	2400.00	4200.00
1980	40	20	80.00	1600.00	20	120.00	2400.00	4200.00
1981	40	20	80.00	1600.00	20	120.00	2400.00	4200.00
1982	40	20	80.00	1600.00	20	120.00	2400.00	4200.00
1983	40	20	80.00	1600.00	20	120.00	2400.00	4200.00
1984	40	20	80.00	1600.00	20	120.00	2400.00	4200.00
1985	40	20	80.00	1600.00	20	120.00	2400.00	4200.00
1986	40	20	80.00	1600.00	20	120.00	2400.00	4200.00
1987	40	20	80.00	1600.00	20	120.00	2400.00	4200.00
1988	40	20	80.00	1600.00	20	120.00	2400.00	4200.00
1989	40	20	80.00	1600.00	20	120.00	2400.00	4200.00
1990	40	20	80.00	1600.00	20	120.00	2400.00	4200.00
1991	40	20	80.00	1600.00	20	120.00	2400.00	4200.00
1992	40	20	80.00	1600.00	20	120.00	2400.00	4200.00

Rate Source: See Table I

TABLE IV

IMPORTATION COSTS-PRESENT IMPORTATION METHOD

(1973-92)

SOUTH INDIAN LAKE

PETROLEUM PRODUCTS

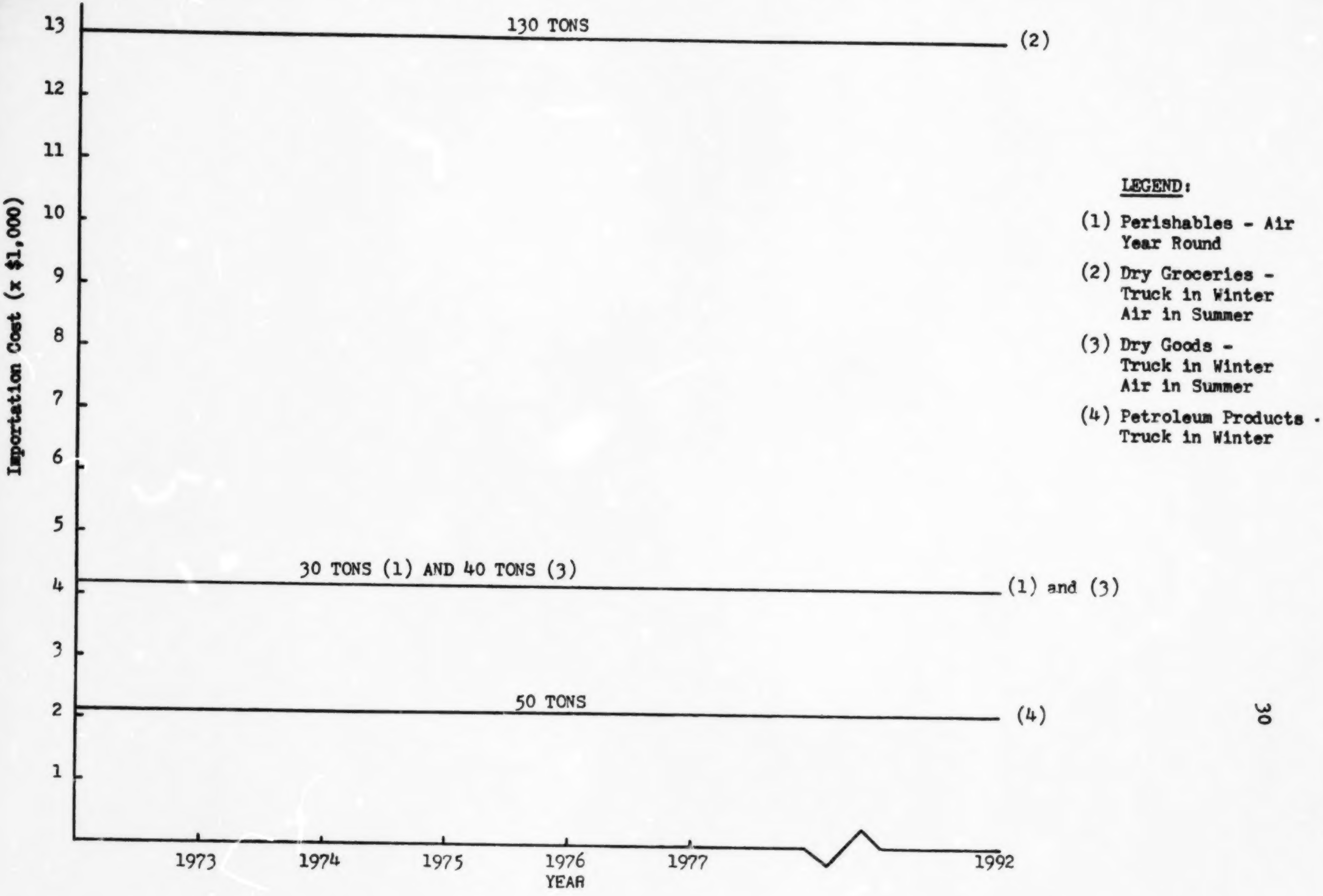
Year	Total Tonnage	Winter Tonnage	Winter Unit Cost $/Ton*	Total Winter Cost $	Summer Tonnage	Summer Unit Cost $/Ton	Total Summer Cost $	Total Annual Cost $
1973	50	50	42.50	2125.00	-	-	-	2125.00
1974	50	50	42.50	2125.00	-	-	-	2125.00
1975	50	50	42.50	2125.00	-	-	-	2125.00
1976	50	50	42.50	2125.00	-	-	-	2125.00
1977	50	50	42.50	2125.00	-	-	-	2125.00
1978	50	50	42.50	2125.00	-	-	-	2125.00
1979	50	50	42.50	2125.00	-	-	-	2125.00
1980	50	50	42.50	2125.00	-	-	-	2125.00
1981	50	50	42.50	2125.00	-	-	-	2125.00
1982	50	50	42.50	2125.00	-	-	-	2125.00
1983	50	50	42.50	2125.00	-	-	-	2125.00
1984	50	50	42.50	2125.00	-	-	-	2125.00
1985	50	50	42.50	2125.00	-	-	-	2125.00
1986	50	50	42.50	2125.00	-	-	-	2125.00
1987	50	50	42.50	2125.00	-	-	-	2125.00
1988	50	50	42.50	2125.00	-	-	-	2125.00
1989	50	50	42.50	2125.00	-	-	-	2125.00
1990	50	50	42.50	2125.00	-	-	-	2125.00
1991	50	50	42.50	2125.00	-	-	-	2125.00
1992	50	50	42.50	2125.00	-	-	-	2125.00

Rate Source: See Table I

* Based on 1 Gallon = 8 lbs.

GRAPH I

IMPORTATION COSTS OF VARIOUS COMMODITIES USING PRESENT METHODS - SOUTH INDIAN LAKE



warrant and the residents request such a facility. It should be noted that the route chosen for such an extension will most certainly be along the west shore of South Bay as the eastern route is far too circuitous. Since the focus of South Indian Lake, the new town center complex, is being built on the east side of the "Narrows" (as mentioned earlier) and provision is being made for the voluntary relocation of residents to the east shore, any road which terminates on the opposite side will likely require a bridge to fully link the community with the Provincial highway system, depending once again on the wishes of the residents in this regard.

No accurate figures are available on the cost of this all-weather road extension. However, a reasonable estimate, based on the cost of the Ruttan Lake - South Bay road which was built over similar terrain, is approximately $1,000,000 with approximately $25,000 required for annual maintenance. The cost of a bridge from the west shore of the Narrows to the east shore is difficult to gauge. For the purposes of this report a figure of $500,000 will be used. This figure by no means represents an exact amount; it is simply an estimate by the authors, and may well prove to be a minimal estimate of cost, depending on the type of bridge structure required.

Tables V - VIII and Graph II represent the annual transport cost of importing the same commodities described earlier with the following additions being made:

a) The above mentioned all-weather road from Ruttan Lake to South Indian Lake and bridge, are assumed to have been built (by sources other than Manitoba Hydro).

TABLE V

IMPORTATION COSTS - EXTENDED METHOD (1973 - 92)

SOUTH INDIAN LAKE

PERISHABLES

Year	Total Tonnage	Winter Tonnage	Winter Unit Cost $/Ton	Total Winter Cost($)	Summer Tonnage	Summer Unit Cost $/Ton	Total Summer Cost($)	Total Annual Freight Cost($)
1973	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1974	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1975	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1976	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1977	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1978	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1979	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1980	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1981	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1982	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1983	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1984	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1985	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1986	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1987	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1988	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1989	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1990	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1991	30	15	140.00	2100.00	15	140.00	2100.00	4200.00
1992	30	15	140.00	2100.00	15	140.00	2100.00	4200.00

Rate Source: Hudson's Bay Company Northern Stores Division

TABLE VI

IMPORTATION COSTS - EXTENDED METHOD (1973 - 92)

SOUTH INDIAN LAKE

DRY GROCERIES

Year	Total Tonnage	Winter Tonnage	Winter Unit Cost $/Ton	Total Winter Cost($)	Summer Tonnage	Summer Unit Cost $/Ton	Total Summer Cost($)	Total Annual Freight Cost($)
1973	130	65	30.60	1989.00	65	30.60	1989.00	3978.00
1974	130	65	30.60	1989.00	65	30.60	1989.00	3978.00
1975	130	65	30.60	1989.00	65	30.60	1989.00	3978.00
1976	130	65	30.60	1989.00	65	30.60	1989.00	3978.00
1977	130	65	30.60	1989.00	65	30.60	1989.00	3978.00
1978	130	65	30.60	1989.00	65	30.60	1989.00	3978.00
1979	130	65	30.60	1989.00	65	30.60	1989.00	3978.00
1980	130	65	30.60	1989.00	65	30.60	1989.00	3978.00
1981	130	65	30.60	1989.00	65	30.60	1989.00	3978.00
1982	130	65	30.60	1989.00	65	30.60	1989.00	3978.00
1983	130	65	30.60	1989.00	65	30.60	1989.00	3978.00
1984	130	65	30.60	1989.00	65	30.60	1989.00	3978.00
1985	130	65	30.60	1989.00	65	30.60	1989.00	3978.00
1986	130	65	30.60	1989.00	65	30.60	1989.00	3978.00
1987	130	65	30.60	1989.00	65	30.60	1989.00	3978.00
1988	130	65	30.60	1989.00	65	30.60	1989.00	3978.00
1989	130	65	30.60	1989.00	65	30.60	1989.00	3978.00
1990	130	65	30.60	1989.00	65	30.60	1989.00	3978.00
1991	130	65	30.60	1989.00	65	30.60	1989.00	3978.00
1992	130	65	30.60	1989.00	65	30.60	1989.00	3978.00

Rate Source: Manitoba Gazette, April 21, 1973

TABLE VII

IMPORTATION COSTS - EXTENDED METHOD (1973 - 92)

SOUTH INDIAN LAKE

DRY GOODS

Year	Total Tonnage	Winter Tonnage	Winter Unit Cost $/Ton	Total Winter Cost($)	Summer Tonnage	Summer Unit Cost $/Ton	Total Summer Cost($)	Total Annual Freight Cost($)
1973	40	20	30.60	612.00	20	30.60	612.00	1224.00
1974	40	20	30.60	612.00	20	30.60	612.00	1224.00
1975	40	20	30.60	612.00	20	30.60	612.00	1224.00
1976	40	20	30.60	612.00	20	30.60	612.00	1224.00
1977	40	20	30.60	612.00	20	30.60	612.00	1224.00
1978	40	20	30.60	612.00	20	30.60	612.00	1224.00
1979	40	20	30.60	612.00	20	30.60	612.00	1224.00
1980	40	20	30.60	612.00	20	30.60	612.00	1224.00
1981	40	20	30.60	612.00	20	30.60	612.00	1224.00
1982	40	20	30.60	612.00	20	30.60	612.00	1224.00
1983	40	20	30.60	612.00	20	30.60	612.00	1224.00
1984	40	20	30.60	612.00	20	30.60	612.00	1224.00
1985	40	20	30.60	612.00	20	30.60	612.00	1224.00
1986	40	20	30.60	612.00	20	30.60	612.00	1224.00
1987	40	20	30.60	612.00	20	30.60	612.00	1224.00
1988	40	20	30.60	612.00	20	30.60	612.00	1224.00
1989	40	20	30.60	612.00	20	30.60	612.00	1224.00
1990	40	20	30.60	612.00	20	30.60	612.00	1224.00
1991	40	20	30.60	612.00	20	30.60	612.00	1224.00
1992	40	20	30.60	612.00	20	30.60	612.00	1224.00

Rate Source: Manitoba Gazette, April 21, 1973

TABLE VIII

IMPORTATION COSTS - EXTENDED METHOD (1973 - 92)

SOUTH INDIAN LAKE

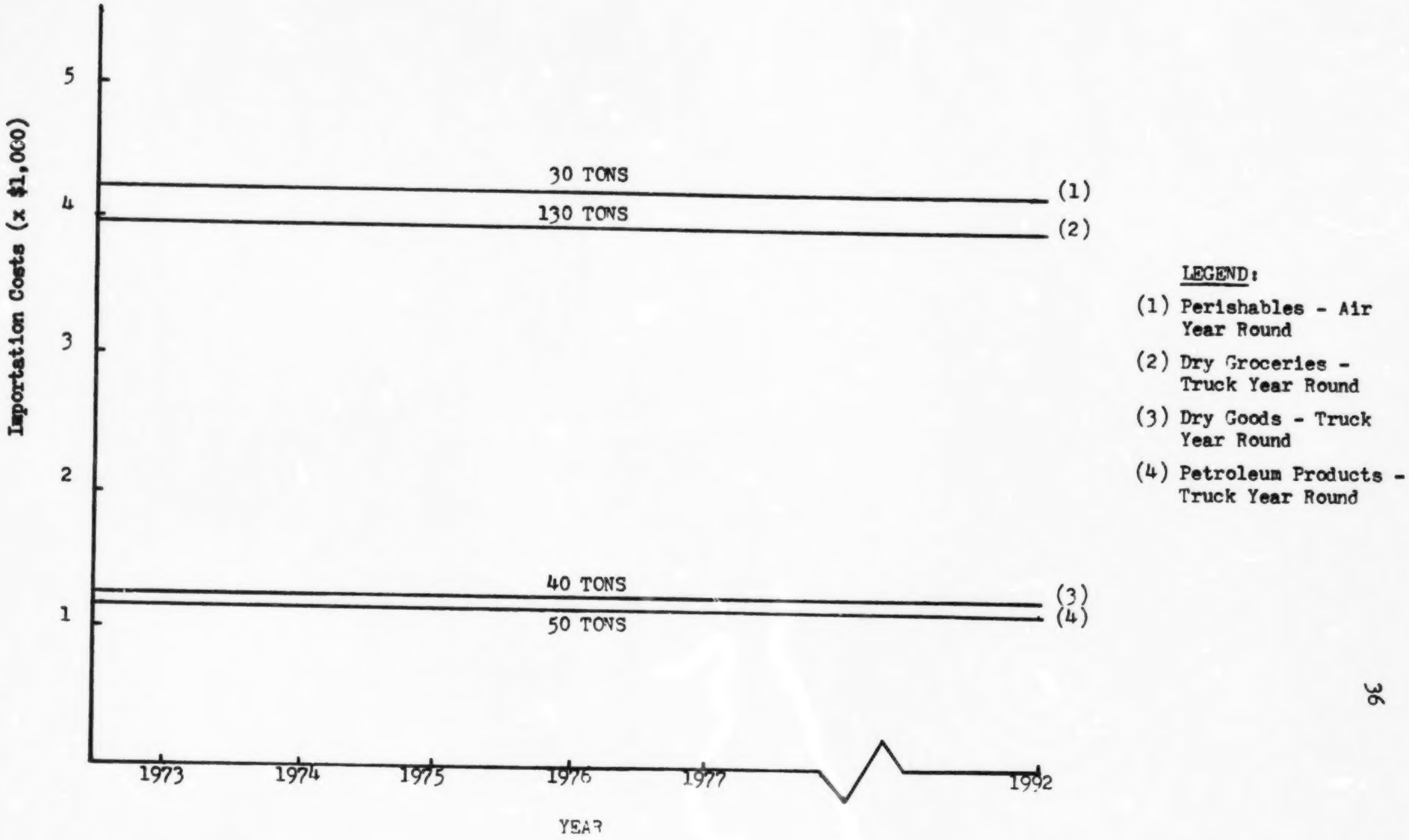
PETROLEUM PRODUCTS

Year	Total Tonnage	Winter Tonnage	Winter Unit Cost $/Ton	Total Winter Cost($)	Summer Tonnage	Summer Unit Cost $/Ton	Total Summer Cost($)	Total Annual Freight Cost($)
1973	50	25	23.40	585.00	25	23.40	585.00	1170.00
1974	50	25	23.40	585.00	25	23.40	585.00	1170.00
1975	50	25	23.40	585.00	25	23.40	585.00	1170.00
1976	50	25	23.40	585.00	25	23.40	585.00	1170.00
1977	50	25	23.40	585.00	25	23.40	585.00	1170.00
1978	50	25	23.40	585.00	25	23.40	585.00	1170.00
1979	50	25	23.40	585.00	25	23.40	585.00	1170.00
1980	50	25	23.40	585.00	25	23.40	585.00	1170.00
1981	50	25	23.40	585.00	25	23.40	585.00	1170.00
1982	50	25	23.40	585.00	25	23.40	585.00	1170.00
1983	50	25	23.40	585.00	25	23.40	585.00	1170.00
1984	50	25	23.40	585.00	25	23.40	585.00	1170.00
1985	50	25	23.40	585.00	25	23.40	585.00	1170.00
1986	50	25	23.40	585.00	25	23.40	585.00	1170.00
1987	50	25	23.40	585.00	25	23.40	585.00	1170.00
1988	50	25	23.40	585.00	25	23.40	585.00	1170.00
1989	50	25	23.40	585.00	25	23.40	585.00	1170.00
1990	50	25	23.40	585.00	25	23.40	585.00	1170.00
1991	50	25	23.40	585.00	25	23.40	585.00	1170.00
1992	50	25	23.40	585.00	25	23.40	585.00	1170.00

Rate Source: Manitoba Department of Industry and Commerce

GRAPH II

IMPORTATION COSTS OF VARIOUS COMMODITIES USING EXTENDED SYSTEM - SOUTH INDIAN LAKE



b) Importation of commodities is altered (with the above road extension in mind) in the following ways:

1. Dry groceries and dry goods are shipped year round by truck from Winnipeg via PTH 6, PR 391 and the Leaf Rapids (-Ruttan Lake - South Bay -) South Indian Lake all-weather road.

2. Perishables continue to be shipped by air from Lynn Lake, year round.

3. Petroleum products are shipped year-round from Thompson via PR 391 and the Leaf Rapids - South Indian Lake all-weather road.

Tables V - VIII and Graph II illustrate the reduction in freight rates and charges brought about by the road extension to the community of South Indian Lake.

However, consideration must now be given to the annual cost associated with this road extension in order to bring the above transport rate and cost reductions into proper perspective.

If the assumption is made that the entire road from Ruttan Lake to South Indian Lake was built without any Manitoba Hydro financial inputs, the annual cost over a twenty year time sequence would be as follows:

Total capital cost of the Ruttan Lake - South Indian Lake road -

$$= \$2,250,000 + \$1,000,000 = \$3,250,000$$

Annual capital cost over twenty years -

$$= \frac{\$3,250,000}{20} = \$162,500$$

Annual maintenance cost (road) -

$$= \$40,000 + \$25,000 = \$65,000$$

Approximate capital cost of bridge = \$500,000

$$\text{Annual capital cost of bridge} = \frac{\$500{,}000}{20} = \$25{,}000$$

Total annual cost of road and bridge -

= \$162,500 + \$65,000 + \$25,000 = \$252,500

These funds would have had to be entirely provided by agencies other than Manitoba Hydro.

The annual cost over a twenty year time sequence of the South Bay - South Indian Lake portion of the above road would represent the actual amount not paid for by Hydro and is as follows:

Total approximate capital cost of South Bay-South Indian Lake road -

= \$1,000,000

Annual capital cost over twenty years -

$$= \frac{\$1{,}000{,}000}{20} = \$50{,}000$$

Approximate annual maintenance (road)

= \$25,000

Approximate capital cost of bridge -

= \$500,000

Annual capital cost of bridge -

$$= \frac{\$500{,}000}{20} = \$25{,}000$$

Total annual cost of road and bridge -

= \$50,000 + \$25,000 + \$25,000 = \$100,000

Therefore, it may be stated that the Hydro initiated Ruttan Lake - South Bay portion of the possible road from Ruttan Lake to South Indian Lake has the effect of reducing the cost of this facility by approximately \$152,500 per year (the non-Hydro inputs total of \$252,500 annually minus the total cost of \$100,000 annually when considering Hydro inputs).

The next stage of the analysis is a comparison of the savings/extra cost ratios for the existing method of importation and the extended infrastructure method as follows:

a) Existing Method

Various combinations of air (summer and winter) and/or road (winter) for all commodities (perishables, dry groceries, dry goods, petroleum products).

The total annual transport cost of all commodity imports to South Indian Lake by the present method (see Tables I - IV and Graph I) is:

Perishables	-	$ 4,200.00
Dry Groceries	-	13,000.00
Dry Goods	-	4,200.00
Petroleum Products	-	2,125.00
Total		$ 23,525.00

b) Extended Road Network (no Hydro input)

Total annual construction and maintenance cost (see analysis earlier in this section) -

= $252,500.00

The total annual transport cost of all commodity imports (both by air and all-weather road) (see Tables V - VIII and Graph II) is:

Perishables	-	$ 4,200.00
Dry Groceries	-	3,978.00
Dry Goods	-	1,224.00
Petroleum Products	-	1,170.00
Total		$ 10,572.00

Annual savings over existing method ((a) above) -

\$23,525.00 - \$10,572.00 = \$12,853.00

Savings/extra cost ratio -

$$= \frac{\$\ 12,853.00}{\$\ 252,500.00} = .051$$

This ratio indicates that the non-Hydro initiated annual infrastructure costs are very high in comparison with the annual savings in importation transport costs.

Therefore the existing method will be chosen for further comparison below.

c) Extended Road Network (with Hydro inputs)

Total annual construction and maintenance cost (see analysis earlier in this section) -

= \$100,000

Total annual cost of all commodity imports (as in (b) above) -

= \$10,572.00

Savings over existing method (as in (b) above) -

= \$12,853.00

Savings/extra cost ratio -

$$= \frac{\$\ 12,853.00}{\$\ 100,000.00} = .1285$$

This ratio, although also indicating a high annual infrastructure cost in comparison with savings in import transport costs, illustrates the effect that Hydro-initiated infrastructure extensions have on reducing the savings/extra cost ratio. The ratio with no financial contributions by Hydro in road construction was .051 compared to .1285 when Hydro contributions were considered.

3. Conclusions

The conclusions which may be drawn from the preceding analysis of the transport costs of importation of commodities to South Indian Lake are:

a) Without the Hydro-initiated road from Ruttan Lake to South Bay, any proposal for an all-weather road connection from Ruttan Lake to South Indian Lake would have had to consider a capital outlay of approximately 3.75 million dollars plus annual maintenance of $65,000 dollars. The financial contribution of Hydro has reduced the cost of this road (i.e. the South Bay - South Indian Lake extension) to approximately 1.5 million dollars plus annual maintenance of $25,000 dollars. On an annual basis, the savings could amount to approximately $152,500 per year.

b) The completion of an all-weather road to the community of South Indian Lake will have the effect of reducing the total annual importation transport costs by approximately 50%, from $23,525.00 for the present importation methods, to $10,572.00 for improved methods utilizing the all-weather road.

C. The Regional Component

1. Commercial Fishery

a) Method of Analysis

The information base for this particular activity with regard to catch, methods of removal and effects of Hydro development is the most adequate of all resource products considered.

The method of approach used is as follows. First, the resource will be identified as to lakes fished and quantity of catch. Then the effects of Hydro development on the fishery in terms of reduction of catch and/or lakes fished will be discussed. Subsequent to this the removal methods currently used will be examined in terms of the effects of Hydro development upon them.

b) Identification of Resource

Southern Indian Lake and its surrounding lakes comprise one of the most important fisheries in Manitoba (about twenty per cent of the total Provincial fish catch[34]) with an average annual summer-winter production of approximately 1,000,000 pounds and a potential catch of approximately 3,000,000 pounds.[35]

Table IX lists the lakes which may presently be fished by the fishermen (members of the South Indian Lake Fisheries Co-operative and of the Ilford Fishermen's Co-operative). Many of the lakes on this list are not fished each year for various reasons: lack of ice for packing, lack of manpower, low returns to fishermen, etc. By far the largest percentage of the catch each year is obtained from Southern Indian Lake itself.

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[34] Information received from Fresh Water Institute, Canada Department of Environment.

[35] Information received from Manitoba Department of Co-operative Development.

TABLE IX

STUDY AREA

COMMERCIAL FISHERY[36]

Lake	Collection Station	Seasonality
Southern Indian	Loon Narrows	Summer and Winter
	Camp Nine	Summer
	Camp Three	"
	Opachuanau	"
North Knife	North End	"
*Etawney	" "*	"
*Billard	" "*	"
Small	" "	"
Wood	" "	"
*Northern Indian	" "*	"
Little Sand	" "	"
Chipewyan	" "	"
Otter	" "	"
Loon	" "	"
Trout	" "	"
Moss	" "	"
Big Sand	" "	"
Denison	" "	"
MacKerracher	" "	"
Partridge Breast	Loon Narrows	"
*Thorsteinson	" " *	"
*Fidler	" " *	"
Gauer	" "	"
Chapman	" "	"
Torrance	" "	"
Cousins	Camp Nine	"
Uhlman	" "	"
Baldock	" "	"
Grandmother	Opachuanau	"
Barlow	"	"
Barrington	Leaf Rapids	"
Eden	" "	"
Costello	" "	"
Suwannee	" "	"
Karsakuwigumak	" "	"
Pemichigamau	" "	"
Mynarski	" "	"
Rat	" "	"
Granville	" "	"

* Fish is transported to Ilford.

[36] Source: Lake Winnipeg-Churchill River Diversion Transportation and Navigation Study and Manitoba Department of Co-operative Development.

c) Effects of Hydro Development on Fishery[37]

Several of the lakes listed in Table IX will not be available for commercial fishing for many years after the Churchill River diversion scheme has been implimented.

The major lakes upstream of Notigi and downstream of South Bay, that is, Lakes Karsakuwigamak, Pemichigamau, Rat and Mynarski, will not be commercially fishable due to the extensive flooding of standing shoreline trees caused by the creation of a forebay upstream of the Notigi control structure. This flooding of shoreline trees will result in large amounts of floating debris which will prevent continuation of the type of net fishing presently used.

Several of the lakes downstream of the Missi Falls control structure, including Partridge Breast, Northern Indian, Fidler and Billard will, to a greater or lesser degree, all experience a drop in water levels post regulation. For example, the average January reduction in water level of Northern Indian Lake will be 12.2 feet while in July it will be 7.3 feet.[38] Although the exact detrimental effect of this water level reduction on the fish population and the corresponding commercial fishery in these lakes has not yet been determined, indications are that it could be substantial.[39]

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[37] Information on effects obtained from Freshwater Institute, Canada Department of the Environment.

[38] Lake Winnipeg, Churchill and Nelson Rivers Study Board Summary of Water Levels and Flow Information received at Seminar Workshop, November 29, 1973.

[39] Based on discussion with members of the Freshwater Institute.

d) Removal Methods - Description and Hydro Development Effects

The present methods of removing fish from the lakes whose production is channeled through the South Indian Lake Fisheries Cooperative are as follows:

1. Fish caught on Southern Indian Lake or its surrounding lakes in summer are brought to one of four collecting stations on Southern Indian Lake or directly to the fish processing plant at Leaf Rapids[40] (see Table IX).

Fish caught on Southern Indian Lake itself are brought by boat to the collection stations while fish caught on outlying lakes are iced at the site and flown to the various collection points (or to the Leaf Rapids plant). From the collection stations, the fish are shipped by refrigerated boat to the fish plant at Leaf Rapids.

2. Fish caught in winter (only Southern Indian Lake is fished) are collected at the Loon Narrows station (see Table IX) and flown to the Leaf Rapids plant.
3. Processed fish are transported year round by truck from Leaf Rapids to Winnipeg via PR 391 and PTH 6.

Apart from eliminating several outlying lakes as potential fisheries (thus reducing the number of air miles flown) and some possible navigational difficulties, the Churchill River diversion project should have little effect on the methods of removing fish from lake to plant. The Leaf Rapids fish processing plant has been established as the center of the operation with water transportation on Southern Indian Lake being the major means of shipping the fish to the plant as noted above. As indicated in Part I of the Southern Indian Lake - Rat-Burntwood Diversion Transportation and Navigation Study (submitted in October, 1973), navigation could be made more difficult on South Indian Lake due to "total or partial inundation of many tiny islands (creating reefs and shallows)". A program of marking such hazards was recommended along with a charting of the Leaf Rapids - South Indian Lake water route as aids to navigation. Should such remedial action be forthcoming the refrigerated fish boats will have little difficulty in travelling between collection stations and Leaf Rapids post regulation.

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[40] As of March, 1974 this plant was temporarily closed. No further details are available regarding its status at this time.

The trucking of processed fish to Winnipeg via PR 391 and PTH 6 should encounter little difficulty as a result of Hydro development. Section IIA of this report examined the effects to PR 391 of increased water levels. Apart from remedial action required near Thompson, no adverse consequences were foreseen.

Thus, it may be stated that apart from minor, rectifiable considerations, the removal of fish from the Southern Indian Lake - Rat-Burntwood Diversion Study Area will be unimpaired by Hydro development.

2. Forestry

a) Method of Analysis

Since the information base for this particular resource activity is very sketchy, the analytical procedure must, of necessity, be simplified as compared to the commercial fishery section. Therefore the discussion of forestry will include a very general description of present and potential production and the possible effects of Hydro development on the removal methods.

b) Present and Potential Production

Present forestry operations have been reported as being "restricted to the need for building materials and fuel for residents of the various communities"[41].

The license to cut merchantable timber in this area is held by Churchill Forest Industries of The Pas, but as yet they have not begun any operations to harvest the resource.

With regard to the forestry production potential in the study area, it could total 20,000 - 30,000 cords per year in the short term and up to 75,000 cords per year, ten to twenty years hence.[42] The difficulty lies in the distance required to transport the timber to The Pas and the lack of feeder roads (roads which branch off PR 391 north and south) which could provide access to the harvestible areas.

It is not known at this time if a large-scale forestry operation will be established in the study area. This will depend upon future demand for the product and the establishment of adequate means of removal.

c) Hydro Development Effects

Hydro development implications for the forestry operations in the area at present are negligible. However, if future demands require the harvesting of the merchantable timber in the area certain factors relating to Hydro development must be considered.

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[41] Lake Winnipeg - Churchill River Diversion Transportation and Navigation Study, April, 1973.

[42] Forestry Branch, Department of Mines, Resources and Environmental Management.

First, the Notigi forebay could provide a means of transporting cut timber from the areas within a few miles of the shoreline from South Bay to Notigi. This timber could be collected near the Notigi dam site and trucked via PR 391 to The Pas directly or to Lynn Lake for furtherance to The Pas by rail. However, the economics of such a venture (i.e. amount of merchantable timber vs. removal costs) as well as accessibility to the resource would have to be considered before any operations could commence.

Similarily, the Wuskwatim and Manasan forebays could also be used to transport cut timber for collection near the Wuskwatim and Manasan control structures. These operations would be dependent upon the above economic considerations, accessibility, and the use of access roads from PR 391 to the control structure sites which will be built by Hydro initially to service the construction of the Wuskwatim and Manasan structures.

3. Mining

a) Description

In the Southern Indian Lake - Rat-Burntwood study area mining operations have become, over the past twenty years, the most important resource industry in terms of employment and production. The discovery of nickel in the vicinity of the City of Thompson by the International Nickel Company Limited in 1957 and at Ruttan Lake, located fifteen miles east of the town of Leaf Rapids, by Sherritt-Gordon Mines Limited in the late 1960's, resulted in the creation of the above mentioned communities as important Northern Manitoba population centers.

b) Hydro Development Effects

With regard to the implications of Hydro development on the above mentioned mining operations, it is highly unlikely that either facility will be adversely affected.

The Ruttan Lake mine is situated several miles to the west of the forebay which will be created by diversion of the Churchill River via South Bay. As such the operation of the mine should not be disrupted in any manner.

The Inco mining operations near Thompson are situated at various sites to the south and east of the city, but at no location do they encroach on that portion of land which will be inundated by the forebay created by the Manasan control structure, and thus will not be adversely affected.

The methods of removing the minerals produced at these mine sites are:

a) Thompson - by rail via the Hudson Bay Branch of the CNR (south to market) and by truck via PR 391 and PTH 6.

b) Ruttan Mine - by truck from the mine site via the Ruttan Lake road and PR 391 to Lynn Lake.

As indicated in the Lake Winnipeg - Churchill River Diversion Transportation and Navigation Study (April, 1973), the rail line and PR 391 at Thompson will suffer no ill effects resulting from Hydro development and thus the removal methods used by Inco will be unaffected as well.

Similarly, as discussed in Part I of this report (submitted in October, 1973), the Ruttan Lake road will not be affected by Hydro development and therefore the method of removing ore concentrates from Ruttan Lake mine will be unaltered.

With regard to any potential mineral operations in the study area and the effects of Hydro development upon them, information concerning specific areas of mineral deposits and reserves is not available at this time; therefore, no comments can be made.

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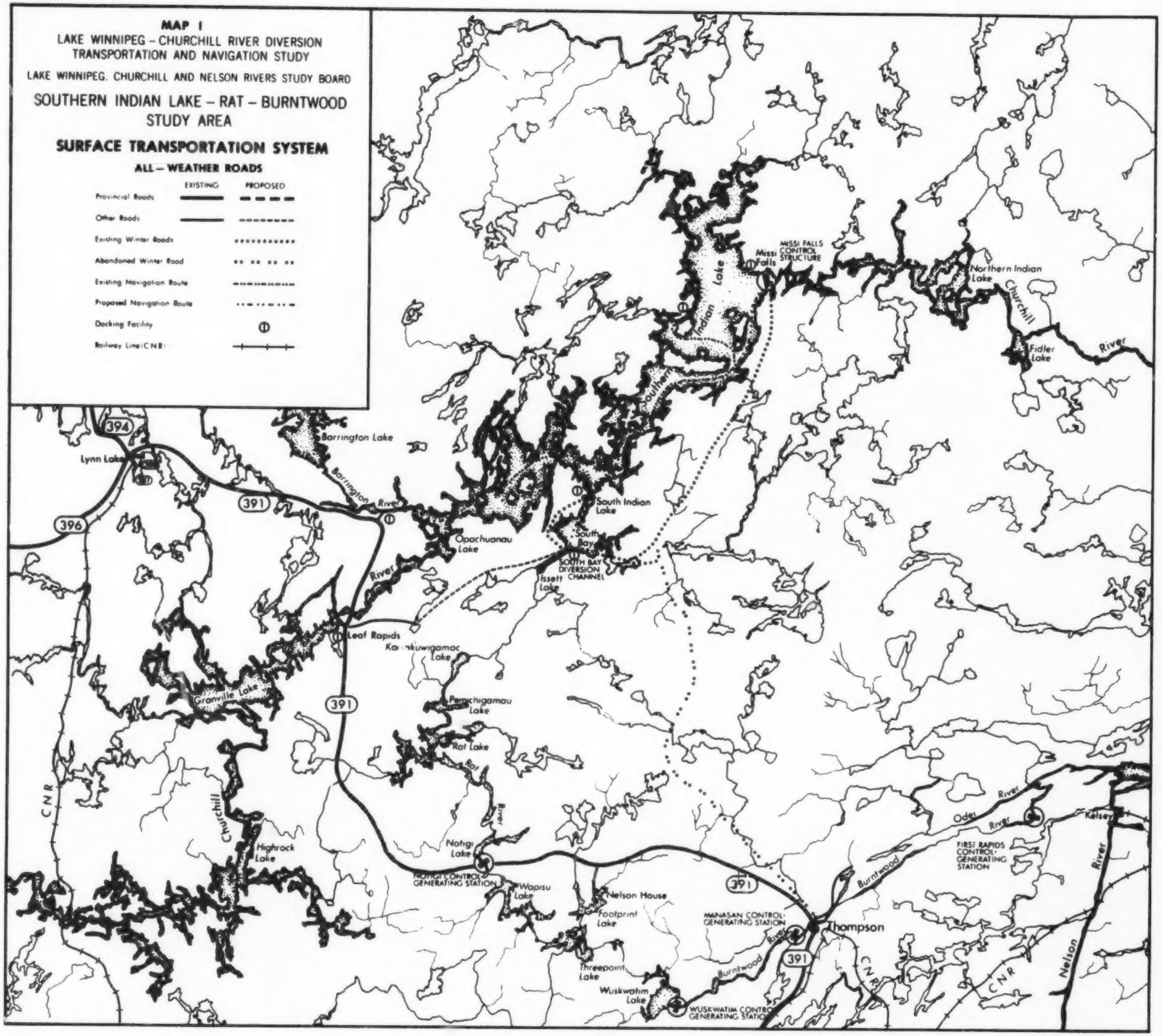
APPENDIX:

MAPS



MAP 1

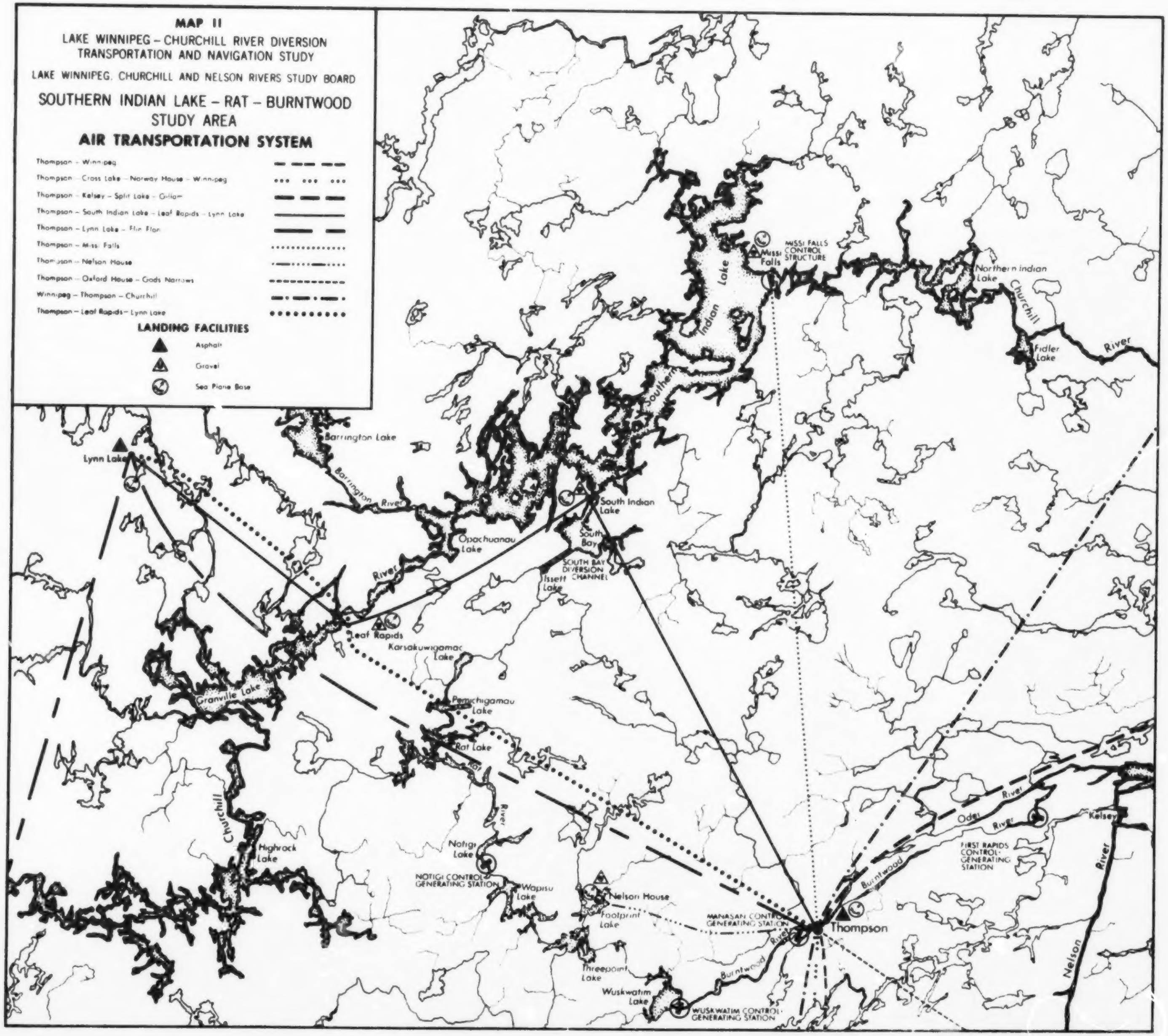
LAKE WINNIPEG – CHURCHILL RIVER DIVERSION
TRANSPORTATION AND NAVIGATION STUDY

LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SOUTHERN INDIAN LAKE – RAT – BURNTWOOD
STUDY AREA

SURFACE TRANSPORTATION SYSTEM

ALL – WEATHER ROADS
EXISTING
PROPOSED
Provincial Roads
Other Roads
Existing Winter Roads
Abandoned Winter Road
Existing Navigation Route
Proposed Navigation Route
Docking Facility
Railway Line(CNR)
394
Lynn Lake
391
396
Barrington Lake
Barrington River
River
Opachuanau Lake
Leaf Rapids
Ka nkuwigamac Lake
Granville Lake
391
Pemichigamau Lake
Rat Lake
Rat
River
CNR
Churchill
Highrock Lake
Notigi Lake
NOTIGI CONTROL GENERATING STATION
Wapisu Lake
Nelson House
Footprint Lake
Threepoint Lake
Wuskwatim Lake
WUSKWATIM CONTROL GENERATING STATION
Burntwood River
MANASAN CONTROL GENERATING STATION
391
Thompson
391
CNR
Burntwood
Odei River
River
FIRST RAPIDS CONTROL GENERATING STATION
Kelsey
Nelson
River
CNR
South Indian Lake
South Bay
SOUTH BAY DIVERSION CHANNEL
Issett Lake
Southern
Indian
Lake
Missi Falls
MISSI FALLS CONTROL STRUCTURE
Northern Indian Lake
Churchill
Fidler Lake
River



MAP II

LAKE WINNIPEG – CHURCHILL RIVER DIVERSION
TRANSPORTATION AND NAVIGATION STUDY

LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

SOUTHERN INDIAN LAKE – RAT – BURNTWOOD
STUDY AREA

AIR TRANSPORTATION SYSTEM

Thompson – Winnipeg
Thompson – Cross Lake – Norway House – Winnipeg
Thompson – Kelsey – Split Lake – Gillam
Thompson – South Indian Lake – Leaf Rapids – Lynn Lake
Thompson – Lynn Lake – Flin Flon
Thompson – Missi Falls
Thompson – Nelson House
Thompson – Oxford House – Gods Narrows
Winnipeg – Thompson – Churchill
Thompson – Leaf Rapids – Lynn Lake
LANDING FACILITIES
Asphalt
Gravel
Sea Plane Base
Missi Falls
MISSI FALLS CONTROL STRUCTURE
Northern Indian Lake
Churchill
Fidler Lake
River
Southern Indian Lake
Barrington Lake
Barrington River
Lynn Lake
South Indian Lake
South Bay
SOUTH BAY DIVERSION CHANNEL
Issett Lake
Opachuanau Lake
River
Leaf Rapids
Karsakuwigamac Lake
Granville Lake
Pemichigamau Lake
Rat Lake
Rat
River
Churchill
Highrock Lake
Notigi Lake
NOTIGI CONTROL GENERATING STATION
Wapisu Lake
Nelson House
Footprint Lake
Threepoint Lake
Wuskwatim Lake
WUSKWATIM CONTROL GENERATING STATION
Burntwood
River
MANASAN CONTROL GENERATING STATION
Thompson
Burntwood
Odei River
River
FIRST RAPIDS CONTROL GENERATING STATION
Kelsey
Nelson
River

LAKE WINNIPEG, CHURCHILL AND NELSON RIVERS STUDY BOARD

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